Project 1CE052P3

”Semi-natural grassland as a source of biodiversity improvement” (SALVERE)

Final Report work package 4

“Seed production quantification”

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Interreg 2007-2013 - Central Europe

The Project SALVERE is implemented through the CENTRAL EUROPE Programme, co-financed by the European Regional Development Funds (European Territorial Cooperation)

Index of Content

a

Index of Figures and Tables

1 Introduction

The general aim of Work package 4 is the assessment of the potential and the real seed production of important species of grassland summing the fertile stems and the number of seeds per stems on a defined area.

2 Seed production quantification

2.1 Meadow considered - Welser Heide

The type of donor community at the donor site Welser Heide is an Arrhenatherion (poor form). The Welser Heide is situated in Upper Austria in a valley between the river Traun and the town Lambach till Hörsching (airport Linz). In earlier time the area was not fertile and consisted of dry sand and gravel fields but through hundreds of years of “Schlierdüngung”, till the 18. century the plain got fertile and a lot of people started to colonize (Kutzenberger, 1996). Through intensive agricultural use and the colonisation the area was almost destroyed. Only the Welser Airport with an area of app. 121 ha is the last part of semi natural grassland and the original Welser Heide. Because of the size and the special flora and fauna (rare species and red list species) it is an interesting area for the EU and the agricultural policy. Till the end of the 1980 30 % of the Welser Airport was still in agricultural use but in the late 90ies the owner (Fliegerclub Weiße Möwe) of the airport started an environmental project. Since 1998 the whole area is free of fertilisation and is mown once a year at the end of June and the biomass will be removed. Within a couple of years the area changed from a nutrient rich and species poor meadow to a species rich Arrhenatherion community. Some red list and rare species appeared (*Dianthus carthusianorum*, *Nurmenius arquata*, *Bufo viridis*) which were extinct in Upper Austria and not found any more (Schuster et al., 2006). Since 2005 a part (1 ha) of the area is used as donor site to harvest site specific seed mixtures.

Figure 1: Donor site Welser Heide in June 2009 at harvesting

Figure 2: Donor site Welser Heide in June 2010 at harvesting

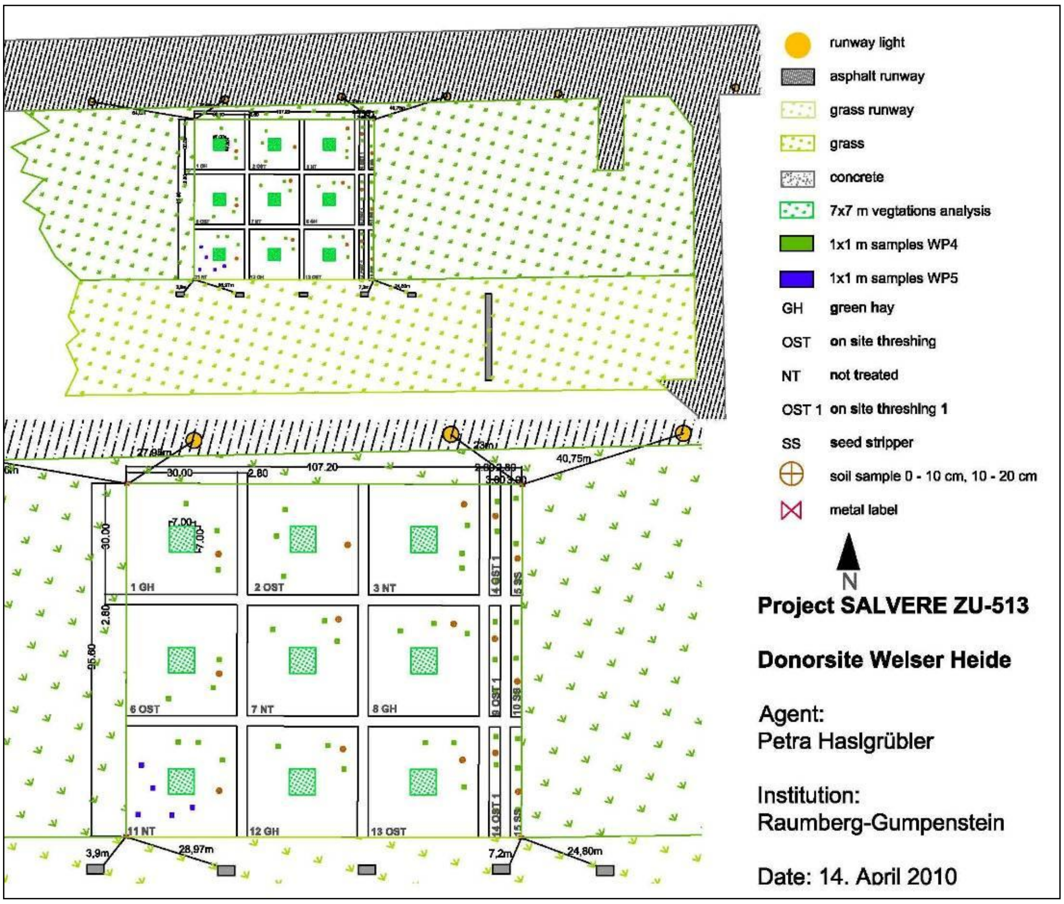


Figure 3: Overview Welser Heide

2.1.1 General description of the donor sites

Location	Wels Airport (figure 3)
Natural landscape unit	Eferdinger basin
Longitude (° from Greenwich)	48° 18' 27" N
Latitude (°)	14° 03' 98" E
Altitude (m a.s..l.)	c. 310 m a.s.l.
Aspect (0 °= North, 90 °=East)	plain
Slope (%)	0 %
Use of the site	Nature reserve
Extension (approx.)	1.5 ha
Geology	Molassezone, fluvial terraces, tertiary accumulation gravel, sand, clay

2.1.2 Climate

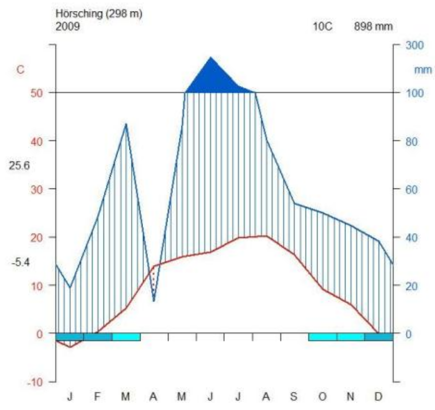


Figure 4: Climate chart 2009 (Weather station in Hörsching near the Welser Heide)

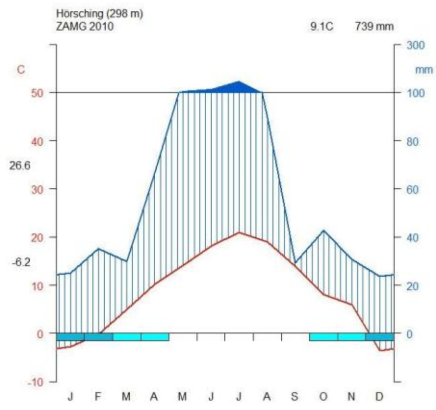


Figure 5: Climate chart 2010 (Weather station in Hörsching near the Welser Heide)

Climate diagrams are brief summaries of average climatic variables and their time course. They have proven useful for a wide range of sciences, industry, and teaching. In bio- and geosciences, they are used as an instrument to show the relationships between soil, vegetation, and climate. The diagrams display monthly averages for temperature and precipitation over a year. Each tic mark along the horizontal line (abscissa) indicates a month. The diagrams start with January in the left corner of the diagram for the northern hemisphere and with July for the southern hemisphere respectively. Thus, the astronomic summer is always shown in the middle of the diagram. 20 mm of monthly precipitation (right ordinate) equal 10°C average temperature (left ordinate). When the precipitation curve undercuts the temperature curve, the area in between them is dotted (every 2 mm) indicating dry season. When the precipitation curve supercedes the temperature curve, vertical lines are plotted for each month (with tic marks every 2 mm) indicating moist season. A very important ecological variable is frost. The diagram shows daily average minimum temperatures below zero in black bars below the horizontal line (Heinrich Walter and Lieth Helmut, 1967). The figures 4 and 5 show the yearly climate, the average temperature and the rainfall of the weather stations Hörsching near the donor site Welser Heide in the year 2009 and 2010. The year 2010 was dryer and cooler than the year 2009.

2.1.3 Yearly meteorology

Description of the climate	**Wels Airport (figure 3)**
Mean yearly rainfall (mm) 1961-1990	753,8 mm
Mean rainfall in spring, summer, autumn and winter (mm)	192, 162, 344, 178
Mean yearly temperature (°C) 1971-2000	8,8°C
Mean date begin vegetation period (mean daily temperature 5°C for sequently fife days)	19th of March
Mean date end vegetation period (mean daily temperature 5°C)	7th of November
Mean length of vegetation period (days)	311

2.1.4 Soil survey of the donor site

Soil of the study sites Arrhenatherion was collected 2009 and 2011 and analysed in order to assess its physical and chemical properties and its fertility. On the 31st of June 2009 the soil depth on the Arrhenatherion meadow was measured in each plot 5 times, the results can be found in table 1. The measurement was done with a metal graduated stake up to a stone or rock. The average of soil depth in every Block is between 7 cm to 7.5 cm. Because of the history of the Welser Heide which was originally a gravel terrace landscape the soil depth is low. The Airport was partly destroyed during the 2nd World War, the gaps were refilled with construction waste.

Table 1: Results of the soil depth in block design from the donor site Welser Heide

	GH	OST	NT	OST/1	SS	Average soil depth
Block 1	7,2	7,8	7,4	7	7,8	7
Block 2	8	6,8	7,6	6,8	7	7,5
Block 3	6,4	8	7,8	7	6,6	7,5

The soil samples of the donor site Welser Heide were collected at two layers (0-10 cm and 10-20 cm) and analysed in the laboratory. In the following table the methods of the analysed parameters are described:

Table 2: Description of analysed soil parameters and used methods

Parameter	unit	discription	method	ÖNORM	extratktions
pH-value	-	pH-value CaCl2-MW		L 1083	
total carbonate	%	Kalkbestimmung			
total phosporus	mg/kg	P205 and K20 after CAL		L 1087/ L 1092	Calciumlactat, HCl
Phosphor	mg/kg	P205 and K20 after CAL	CAL Method	L 1087/ L 1092	Calciumlactat, HCl
Potassium	mg/kg	P205 and K20 after CAL	CAL Method	L 1087	Calciumlactat, HCl
Plant available magnesium	mg/kg	magnesium Schachtschabl		l 1093	
organic matter content	%	650°C TOC - carbon	dry burning	L 1080	
total nitrogen	%	total nitrogen		L 1095	
sand	%	grain size definition (3)	grain size <2000 µm - 63 µm		
gley	%	grain size definition (3)	grain size <63 µm - 2 µm		
lime clay	%	grain size definition (3)	grain size <2 µm	L 1061-2	

The results of the analysed soil parameters from the Welser Heide are in table 3. The grain size between sand and clay is around 40 % to 45 % which is in a good balance and typical for semi dry communities. Lime clay with 11 % is low. A high percentage of the grain size between <2000 µm to 63 µm has a low nutrient content, low water holding capacity, intensive soil aeration and easy machinability (Blum, 1992). The pH-value is neutral to alkaline (6,3 – 7,4). The pH-value for this kind of community is in a reasonable area (Oberdorfer, 2001). Phosphorus with < 20,7 mg/kg and potassium with <112,3 mg/kg are extremely low. On all variants are carbonate, the plant available magnesium and nitrogen are high for an Arrhenatherion community. The organic matter content is measured in percent and the soil is in the category strong humus (> 6,6 %) (BMLFUW, 2006).

Table 3 Analysed parameters of the Arrhenatherion community Welser Heide

sample	sand [%]	gley [%]	lime clay [%]	total nitrogen [%]	total phosporus [mg/kg]	total potassium [mg/kg]	Plant available magnesium [mg/kg]	total carbonate [%]	pH-value	organic matter content [%]
GH 0-10 cm	43.15	45.15	11.75	0.66	16.00	99.33	570.00	7.97	6.92	13.57
GH 10-20 cm	43.80	43.47	12.80	0.44	13.00	49.67	416.00	12.33	7.22	8.27
OST 0-10 cm	47.40	42.00	10.60	0.67	19.33	112.33	552.67	7.93	7.01	14.33
OST 10-20 cm	42.37	41.63	12.73	0.36	13.00	39.67	321.33	22.17	7.25	6.60
NT 0-10 cm	40.10	44.45	15.45	0.66	16.67	112.00	543.67	9.23	6.98	13.77
NT 10-20 cm	45.10	42.33	12.60	0.37	8.33	47.33	343.00	19.10	7.24	6.83
OST1 0-10 cm	43.70	44.05	12.20	0.60	19.33	93.33	520.00	11.20	7.15	12.67
OST1 10-20 cm	44.83	43.23	11.93	0.39	13.00	41.33	348.33	18.37	7.36	7.27
SS 0-10 cm	44.53	45.20	10.27	0.62	18.33	98.67	523.33	8.87	7.17	12.70
SS 10-20 cm	46.40	42.17	11.43	0.43	20.67	45.00	365.67	15.70	7.34	7.90

2.1.5 Species considered at the donor site Welser Heide

Table 4 Species considered Welser Heide

GRASSES	GRÄSER
1.Arrhenatherum elatius	Glatthafer
2.Avenula pubescens	Flaumhafer
3.Bromus erectus	Aufrechte Trespe
4.Dactylis glomerata	Knaulgras
5.Festuca pratensis	Wiesenschwingel
6.Festuca rupicola	Furchenschwingel
7.Poa pratensis	Wiesen Rispe
8.Trisetum flavescens	Goldhafer
LEGUMES	LEGUMINOSEN
9.Anthyllis vulneraria	Echter Wundklee
10.Medicago campestre	Feldklee
11.Trifolium pratense	Rotklee
FORBS	KRÄUTER
12.Dianthus carthusianorum	Eigentliche Kartäuser Nelke
13.Galium album	Großes Wiesenlabkraut
14.Knautia Arvensis	Witwenblume
15.Plantago Lancelota	Spitzwegerich
16.Salvia pratensis	Wiesensalbei

2.2 Analysis of fertile stems at seed maturation

For each species described in table 4 - 30 fertile stems were collected at stage of middle-late seed maturity. This means that no or only a few seeds or fruits could have fallen out. The sizes of the inflorescences (defined separately for each target specie in Table 5) of the 30 fertile stems covers the whole range of size variability.

Table 5 Measurement of the size of the inflorescences Welser Heide

GRASSES	Inflorescence size
1.Arrhenatherum elatius	inflorescence length (mm)
2.Avenula pubescens	inflorescence length (mm)
3.Bromus erectus	inflorescence length (mm)
4.Dactylis glomerata	inflorescence length (mm)
5.Festuca pratensis	inflorescence length (mm)
6.Festuca rupicola	inflorescence length (mm)
7.Poa pratensis	inflorescence length (mm)
8.Trisetum flavescens	inflorescence length (mm)
LEGUMES	LEGUMINOSEN
9.Anthyllis vulneraria	flower head diameter (mm)
10.Medicago campestre	analysis not possible
11.Trifolium pratense	flower head diameter (mm)
FORBS	KRÄUTER
12.Dianthus carthusianorum	analysis not possible
13.Galium album	analysis not possible
14.Knautia Arvensis	analysis not possible
15.Plantago Lancelota	inflorescence length (mm)
16.Salvia pratensis	central & lateral spike length (mm)

2.3 Date of collection at the donor site Welser Heide

The collection date is different for each species. The collection period at the Welser Heide was between 26th June and 16th July in 2010 and between 9th June and 6th July in 2011. According to the dry weather conditions in spring 2011 and bad weather conditions before harvest in 2010 the harvest in 2011 was up to 10 days earlier than the year before.

Table 6 Date of collection Welser Heide

number	name	german name	yield date 2010	yield date 2011
1	Arrhenatherum elatius	Glatthafer	26. June 2010	24. June 2011
2	Avenula pubescens	Flaumhafer	26. June 2010	9. June 2011
3	Bromus erectus	Aufrechte Trespe	26. June 2010	24. June 2011
4	Dactylis glomerata	Knaulgras	26. June 2010	24. June 2011
5	Festuca pratensis	Wiesen-Schwingel	26. June 2010	23. June 2011
6	Festuca rupicola	Furchen-Schwingel	26. June 2010	24. June 2011
7	Poa pratensis	Wiesen-Rispe	26. June 2010	14. June 2011
8	Trisetum flavescens	Goldhafer	26. June 2010	24. June 2011
9	Anthyllis vulneraria	Nordischer Wundklee	26. June 2010	6. Jule 2011
10	Trifolium campestre	Feld-Klee	16. July 2010	6. July 2011
11	Trifolium pratense	Rot-Klee	16. July 2010	6. July 2011
12	Dianthus carthusianorun	Eigent. Karthäuser-Nelke	26. June 2010	24. June 2011
13	Galium album	Großes Wiesen-Labkraut	16. July 2010	6. July 2011
14	Knautia arvensis	Gew. Wiesen-Witwenblum	16. July 2010	6. July 2011
15	Plantago lanceolata	Spitz-Wegerich	16. July 2010	6. July 2011
16	Salvia pratensis	Wiesen-Salbei	26. June 2010	14. June 2011

2.4 Analyses and results of the fertile stems

Table 7 shows the average results of the fertile stem analyses (number of inflorescences, size of the inflorescences, number of fertile spikelets, and number of seeds per fruit) of 2010 and 2011. In 2011, the average size of the inflorescence of the species was about 20 % lower (between 10 % and 35 %) than in 2010. Except of *Bromus erectus*, *Poa pratensis* and *Trifolium pratense* where an increase of size of the inflorescence by about 10 % occurred. The size of the inflorescence of *Plantago lanceolata* was in 2010 about the same as in 2011.

Table 7 Welser Heide average of 30 fertile stems 2010 and 2011

number	name	german name	Minimum size of the inflorescence (mm)	Maximum size of the inflorescence (mm)	Average size of inflorescence (mm)	Mean number of fertile spikelets	Mean number of seeds	seeds per mm
1	Arrhenatherum elatius	Glatthafer	105	205	150	52	35	0,23
2	Avenula pubescens	Flaumhafer	88	171	113	32	46	0,40
3	Bromus erectus	Aufrechte Trespe	74	142	109	19	48	0,44
4	Dactylis glomerata	Knaulgras	47	126	78	53	198	2,47
5	Festuca pratensis	Wiesen-Schwingel	73	184	136	29	26	0,19
6	Festuca rupicola	Furchen-Schwingel	32	85	53	16	16	0,29
7	Poa pratensis	Wiesen-Rispe	54	112	73	42	190	2,57
8	Trisetum flavescens	Goldhafer	51	118	90	111	116	1,11
9	Anthyllis vulneraria	Nordischer Wundklee	10	28	17	9	8	0,48
10	Trifolium campestre	Feld-Klee	relation between length of inflorescence and semen not possible					
11	Trifolium pratense	Rot-Klee	6	14	12	42	9	0,77
12	Dianthus carthusianorum	Eigent. Karthäuser-Nelke	relation between length of inflorescence and semen not possible					
13	Galium album	Großes Wiesen-Labkraut	relation between length of inflorescence and semen not possible					
14	Knautia arvensis ssp.arvensis	Gew. Wiesen-Witwenblume	relation between length of inflorescence and semen not possible					
15	Plantago lanceolata	Spitz-Wegerich	11	38	20	60	38	1,92
16	Salvia pratensis	Wiesen-Salbei	33	198	104	18	21	0,20

A very interesting result showed in Table 7 is the relation between the average size of the inflorescence and the mean number of seeds. The value - seeds per millimetre offers a simple way to estimate the seed yield of a specific site by extrapolating the results of measuring the size of inflorescence in a testing plot to the whole site. These results are almost like the linear regression showed in chapter 4.3. The validity of this value should be evaluated in further research. This relation can be an alternative to the compilation of the regressions.

2.5 Analysis and the Results of the fertile stem density

The collection of all fertile stems of the target species considered present on nine 1 x 1 m plots (3 for each not treated block) was done in summer 2010 and 2011. For each species the collection has been done at the same time as harvesting for work package 5. For each species, the number of fertile stems was assessed and the number of inflorescences present counted and for each inflorescence the size measured.

The results are the average values of fertile stems per m^{-2}, the inflorescence size and the produced seeds and shown in Table 8. This result gives an impression of how many seeds per square meter could be harvested at the date of collection, how much seeds could have been collected at the whole site.

Table 8 Welser Heide average of harvesting 2010 and 2011

number	name	german name	Average Number per 1x1m	Average size inflorescence (mm)	Average n. of produced seeds per 1*1m
1	Arrhenatherum elatius	Glatthafer	2,65	108,5	81
2	Avenula pubescens	Flaumhafer	27,85	93,5	1030
3	Bromus erectus	Aufrechte Trespe	0,2	32	5
4	Dactylis glomerata	Knaulgras	0,5	51	57
5	Festuca pratensis	Wiesen-Schwingel	0,55	50,5	9
6	Festuca rupicola	Furchen-Schwingel	0,1	17	0,5
7	Poa pratensis	Wiesen-Rispe	4,2	64,5	743
8	Trisetum flavescens	Goldhafer	1,05	66,5	106
9	Anthyllis vulneraria ssp.vulneraria	Nordischer Wundklee	0	0	0
10	Trifolium campestre	Feld-Klee	relation between length of inflorescence and semen not possible		
11	Trifolium pratense	Rot-Klee	0,04	1,5	0
12	Dianthus carthusianorum	Eigent. Karthäuser-Nelke	relation between length of inflorescence and semen not possible		
13	Galium album	Großes Wiesen-Labkraut	relation between length of inflorescence and semen not possible		
14	Knautia arvensis ssp.arvensis	Gew. Wiesen-Witwenblume	relation between length of inflorescence and semen not possible		
15	Plantago lanceolata	Spitz-Wegerich	1,75	15,5	52
16	Salvia pratensis	Wiesen-Salbei	4,4	79	71

The detailed data shows that there was a significant change between the fertile stems density of *Poa pratensis* and *Dactylis glomarata* between 2010 and 2011. Their occurrence doubled in expense of *Arrhenathrum elatius* that decreased by more than 60%.

2.6 Phenological survey of the Welser Heide

The following table shows the results of the phenological survey from the donor sites Welser Heide. The botanical survey at the Welser Heide was done on 30 June 2009 on every plot in a subplot of 7x7m (figure 3). The subplot is in the centre of the plot to avoid border effects. A survey of the phenological stadium of the meadow was done once just before harvesting. A list of all present species was done on the subplot. The Arrhenatherion meadow Welser Heide was harvested on the 1 July 2009.

On each plot just before harvesting the phonological stage of each species was determined with the following the codes of BBCH. *Echium vulgare* was the only species which was in the category 50-59 Inflorescence emergence (main shot)/ heading. 8 species (3 grasses and 5 herbs) from the list in Table 6 are in the range 60-69 Flowering (main shoot) and developing their fruits. In the category 70-79 are 18 species (1 grass and 17 herbs) and developing their fruits. Most of the species (38) were in the category 80-89 Ripening or maturity of fruit and seed. From the 38 species 16 are grasses and 22 herbs. At the harvesting time 01 July 2009 almost all grasses were ripe. Most herbs reach maturity later and have a longer ripening time. To collect all species two harvesting dates would be recommendable. An early one in June to harvest the most of the ripe grasses and legumes and a late on in July to harvest the herbs and mix it (Hölzel and Otte, 2003). In this case all species of a community would be in the mixture.

Table 9: Results of the phenological stage according to the BBCH-code

species		range
Echium vulgare	56	50-59 Inflorescence emergence (main shoot) / heading
Thymus praecox	61	60- 69 Flowering (main shoot)
Agrostis gigantea	65	
Securigera varia	65	
Sedum sexangulare	65	
Achillea millefolium agg.	67	
Apera spica-venti	69	
Medicago falcata	69	
Hypericum perforatum	69	
Galium album	70	70-79 Development of fruit
Lotus corniculatus	71	
Galium verum	71	
Trifolium campestre	72	
Convolvulus arvensis	72	
Euphorbia esula	73	
Phleum pratense	75	
Galium pycnotrichum	75	
Plantago media	75	
Potentilla sterilis	75	
Sanguisorba minor	75	
Veronica chamaedrys	75	
Veronica serpyllifolia	75	
Vicia cracca	75	
Foeniculum vulgare	76	
Pastinaca sativa	76	
Pimpinella major	76	
Plantago major	79	
Elymnus repens	81	80-89 Ripening or maturity of fruit and seed
Trifolium pratense	81	
Centaurea jacea	81	
Centaurea stoebe	81	
Daucus carota ssp.carota	81	
Rumex acetosella	81	
Bromus erectus	85	
Dactylis glomerata	85	
Medicago lupulina	85	
Trifolium repens	85	
Fallopia arvensis	85	
Knautia arvensis	85	
Plantago lanceolata	85	
Bromus sterilis	87	
Festuca pratensis	87	
Festuca rubra	87	
Poa annua	87	
Silene vulgaris	87	
Anthoxanthum odoratum	89	
Arrhenatherum elatius	89	
Avenula pubescens	89	
Bromus hordeaceus	89	
Festuca rupicola	89	
Poa trivialis	89	
Poa angustifolia	89	
Poa pratensis	89	
Trisetum flavescens	89	
Anthyllis vulneraria	89	
Campanula patula	89	
Cerastium holosteoides	89	
Dianthus carthusianorum	89	
Leontodon hispidus	89	
Leucanthemum vulgare agg.	89	
Myosotis sp.	89	
Orobanche sp.	89	
Rhinanthus sp.	89	
Salvia pratensis	89	
Taraxacum officinale	89	

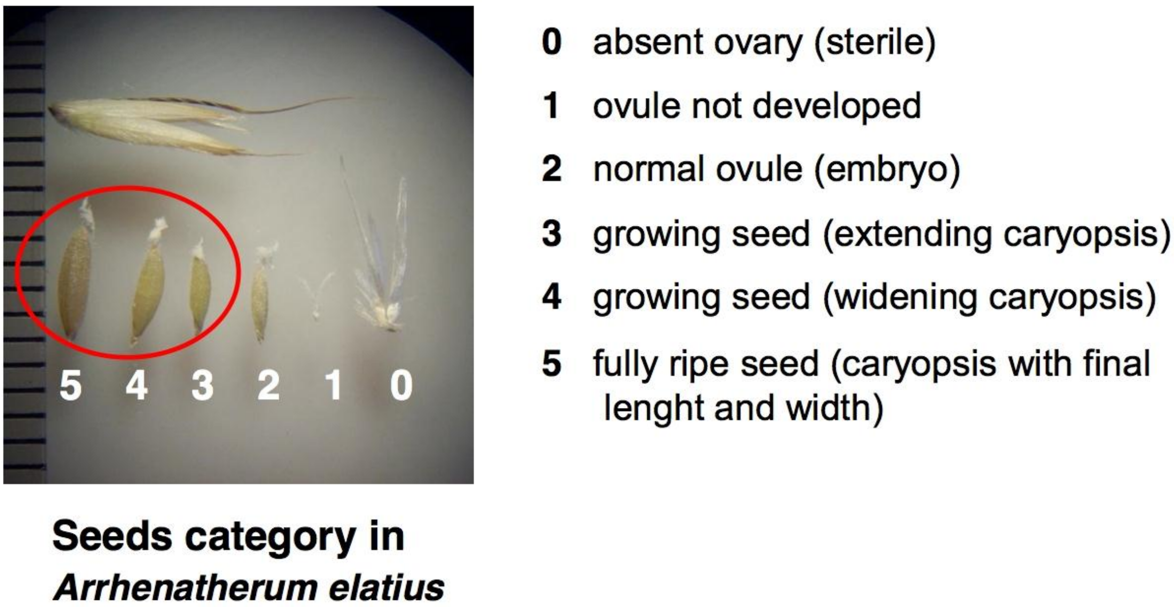
3 Evaluation of seed quality

The general aim is assessing the seed quality of important species. The seed production quantifications like community, site, meadow, climate, soil and management, species considered and the collection of fertile stems at seed maturity are described in the final report 4.1.

3.1 Separation of the mature seeds

According to the common method, only seed in the category 4 - growing seed (widening caryopsis) and 5 - fully ripe seed (caryopsis with final length and width) were counted. See the example in figure 1.

Figure 6: Seeds category - (picture by Claudia Dal Buono – Lead Partner)



3.2 Assessment of thousand seed weight (TSW)

According to the international seed testing association ((ISTA, 2011)), the thousand seed weight in 2010 and 2011 were compiled. Table 1 shows the average thousand seed weight of 2010 and 2011.

Table 10: Average of TSW 2010 and 2011

number	name	german name	thousand seeds weight 2010	thousand seeds weight 2011	thousand seeds weight average
1	Arrhenatherum elatius	Glatthafer	2,69	3,858	3,27
2	Avenula pubescens	Flaumhafer	1,46	2	1,73
3	Bromus erectus	Aufrechte Trespe	4,003	5,131	4,57
4	Dactylis glomerata	Knaulgras	0,952	1,172	1,06
5	Festuca pratensis	Wiesen-Schwingel	2,215	1,876	2,05
6	Festuca rupicola	Furchen-Schwingel	0,854		0,85
7	Poa pratensis	Wiesen-Rispe	0,306	0,175	0,24
8	Trisetum flavescens	Goldhafer	0,261	0,203	0,23
9	Anthyllis vulneraria	Nordischer Wundklee	4,2	3,145	3,67
10	Trifolium campestre	Feld-Klee	0,352		0,35
11	Trifolium pratense	Rot-Klee	1,358	1,372	1,37
12	Dianthus carthusianorum	Eigent. Karthäuser-Nelke	0,683	0,806	0,74
13	Galium album	Großes Wiesen-Labkraut	0,734	0,716	0,73
14	Knautia arvensis	Gew. Wiesen-Witwenblume	4,22	4,814	4,52
15	Plantago lanceolata	Spitz-Wegerich	1,614	0,846	1,23
16	Salvia pratensis	Wiesen-Salbei	1,513	1,46	1,49

The thousand seed weight differs between the years 2010 to 2011 between all species, some grasses had a higher TSW in the year 2011 (for example *Arrhenaterium elatius*, *Avenula pubescens*) in comparison to 2010 and some grasses had a lower TSW (for example *Festuca pratensis*, *Poa pratensis*). The comparison of the leguminosae demonstrates a higher TSW in 2010, the forbs show a higher TSW in 2010 compared to 2011, except *Dianthus carthusianorum* and *Knautia arvensis*.

3.3 Assessment of seed size

The analysis of length and diameter measured on 30 seeds was done in autumn 2010 and 2011 in the laboratories at AREC Raumberg-Gumpenstein. The picture below shows for example an *Arrenatherum elatius* seed. The “length I” is according to the body of the seed, “length II” is - if existing - for the awn.

Figure 7: Example measurement for Arrenatherum elatius

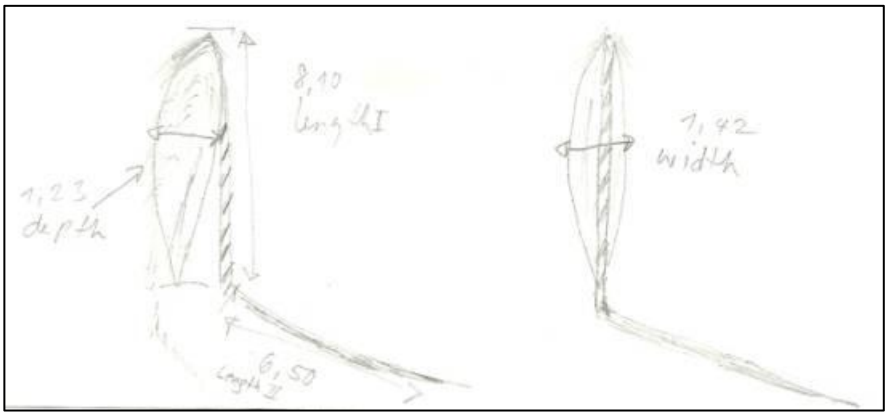


Table 2 shows the result of the assessment of seed size; the length ranges from 1,14mm (*Trifolium campestre*) to 10,25mm (*Bromus erectus*), the width from 0,44mm (*Trisetum flavescens*) to 2,05mm and the depth from 0,39 (*Festuca rupicola*) to 1,63 (*Anthyllis vulneraria*).

Table 11: Evaluation of the average of seed size 2010 and 2011 in mm

name	german name	Length I	length II	width	depth
Arrhenatherum elatius	Glatthafer	7,81	4,05	1,73	1,31
Avenula pubescens	Flaumhafer	10,16	6,67	1,04	0,84
Bromus erectus	Aufrechte Trespe	10,25	4,74	1,28	0,96
Dactylis glomerata	Knaulgras	5,36	0,67	1,15	0,90
Festuca pratensis	Wiesen-Schwingel	6,01	0,00	1,44	0,89
Festuca rupicola	Furchen-Schwingel	2,30	1,08	0,55	0,39
Poa pratensis	Wiesen-Rispe	2,54	0,00	1,36	0,66
Trisetum flavescens	Goldhafer	5,62	2,38	0,44	0,72
Anthyllis vulneraria ssp.vulneraria	Nordischer Wundklee	3,15	0,00	2,05	1,63
Trifolium campestre	Feld-Klee	1,14	0,00	0,77	0,62
Trifolium pratense	Rot-Klee	1,72	0,00	2,61	1,19
)ianthus carthusianoru	igent. Karthäuser-Nelk	2,06	0,00	1,60	0,51
Galium album	Großes Wiesen-Labkraut	1,36	0,00	1,04	0,94
autia arvensis ssp.arver	w. Wiesen-Witwenblu	4,47	0,00	1,52	1,60
Plantago lanceolata	Spitz-Wegerich	2,58	0,00	1,04	0,65
Salvia pratensis	Wiesen-Salbei	2,38	0,00	1,57	1,19

3.4 Assessment of seed germinability

The analyses according to the rules of ISTA were done in winter 2010 and autumn 2011 at the laboratories of AREC Raumberg-Gumpenstein. At AREC, the assessment of germination rate is done with the Jacobsen apparatus. It consists mainly of a germination plate being temperature-regulated by the water basin below. The water bath is equipped with an automatic temperature control. The germination spirals being equipped with a paper substrate that is placed on the germination plate. The wick is being led through slots in the germination plate and reaches into the water bath below, thus supplying the required humidity and the desired temperature to the paper substrate. The circular filter papers are covered with a transparent or dark cover dome to provide the air humidity being required for the germination. A small hole in the upper end of the dome ensures sufficient supply of fresh air and minimum evaporation at the same time. Units being executed with active cooling allow day-night temperature alternation, as well as any temperature profile (ISTA, 2011).

Figure 8: Jacobsen apparatus at AREC

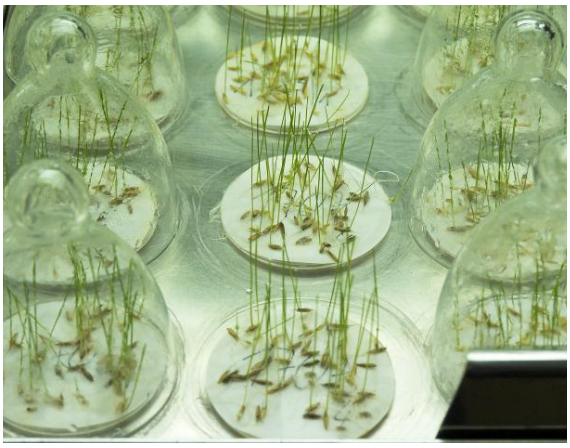


Figure 9: Germinated seeds on the Jacobsen apparatus

3.4.1 Results of seed germination capacity

The results in the table 3 show that in 57 % of the cases the germination rate was too low according to the ISTA Rules (ISTA 2011). Four species do not even reach a germination capacity of 30%.

Table 12: Germination capacity of the different species in 2010

number	name	german name	Substrat	temperature	yield date	dead	sprout	minimum sprout	status sprout
1	Arrhenatherum elatius	Glatthafer	Jakobsen	20-30°C	26. Juni 2010	58	43	75	germination too little
2	Avenula pubescens	Flaumhafer	Jakobsen	20-30°C	26. Juni 2010	82	19	70	germination too little
3	Bromus erectus	Aufrechte Trespe	Jakobsen	15-25°C	26. Juni 2010	22	79	75	germination all right
4	Dactylis glomerata	Knaulgras	Jakobsen	15-25°C	26. Juni 2010	19	82	80	germination all right
5	Festuca pratensis	Wiesen-Schwingel	Jakobsen	15-25°C	26. Juni 2010	15	86	80	germination all right
6	Festuca rupicola	Furchen-Schwingel	Jakobsen	20-30°C	26. Juni 2010	22	79	75	germination all right
7	Poa pratensis	Wiesen-Rispe	Jakobsen	15-25°C	26. Juni 2010	52	49	75	germination too little
8	Trisetum flavescens	Goldhafer	Jakobsen	20-30°C	26. Juni 2010	29	72	70	germination all right
9	Anthyllis vulneraria	Nordischer Wundklee	sproutcup with filter paper	20°C	26. Juni 2010	1	3	75	germination too little
10	Trifolium campestre	Feld-Klee	sproutcup with filter paper	20°C	16. Juli 2010		1	75	germination too little
11	Trifolium pratense	Rot-Klee	sproutcup with filter paper	20°C	16. Juli 2010	7	44	80	germination too little
12	Dianthus carthusianorum	Eigent. Karthäuser-Nelk	Jakobsen	20-30°C	26. Juni 2010	16	85	60	germination all right
13	Galium album	Großes Wiesen-	Jakobsen	15-25°C	16. Juli 2010	9	92	70	germination too little
14	Knautia arvensis	Wiesen-Witwenblume	Jakobsen	20-30°C	16. Juli 2010	48	53	50	germination all right
15	Plantago lanceolata	Spitz-Wegerich	Jakobsen	20-30°C	16. Juli 2010	10	91	70	germination all right
16	Salvia pratensis	Wiesen-Salbei	Jakobsen	20-30°C	26. Juni 2010	71	30	50	germination too little

In the year 2011, the germination capacity of some species (*Arrhenatherum elatius, Avenula pubescens, Bromus erectus, Dactylis glomerata, Poa pratensis, Anthyllis vulneraria, Galium album, Salvia pratensis)* is higher than in 2010, some species present a lower germination capacity (*Festuca pratensis, Trisetum flavescens, Trifolium pratense, Dianthus carthusianorum, Knautia arvensis, Plantago lancelota).*

Table 13: Germination capacity of the different species in 2011

number	name	german name	Substrat	temperature	yield date	dead	sprout	minimum sprout	status sprout
1	Arrhenatherum elatius	Glatthafer	Jakobsen	20-30°C	24. Juni 2011	24	76	75	germination all right
2	Avenula pubescens	Flaumhafer	Jakobsen	20-30°C	9. Juni 2011	63	38	70	germination too little
3	Bromus erectus	Aufrechte Trespe	Jakobsen	15-25°C	24. Juni 2011		98	75	germination all right
4	Dactylis glomerata	Knaulgras	Jakobsen	15-25°C	24. Juni 2011	14	87	80	germination all right
5	Festuca pratensis	Wiesen-Schwingel	Jakobsen	15-25°C	23. Juni 2011	22	79	80	germination too little
6	Festuca rupicola	Furchen-Schwingel	not enough seeds available		24. Juni 2011				
7	Poa pratensis	Wiesen-Rispe	Jakobsen	15-25°C	14. Juni 2011	20	81	75	germination all right
8	Trisetum flavescens	Goldhafer	Jakobsen	20-30°C	24. Juni 2011	44	47	70	germination too little
9	Anthyllis vulneraria	Nordischer Wundklee	Jakobsen	20°C	6. Juli 2011	9	28	75	germination too little
10	Trifolium campestre	Feld-Klee	not enough seeds available		6. Juli 2011				
11	Trifolium pratense	Rot-Klee	Jakobsen	20°C	6. Juli 2011	20	22	80	germination too little
12	Dianthus carthusianorum	Eigent. Karthäuser-Nelke	Jakobsen	20-30°C	24. Juni 2011	22	79	60	germination all right
13	Galium album	Großes Wiesen-Labkraut	Jakobsen	15-25°C	6. Juli 2011	3	97	70	germination all right
14	Knautia arvensis ssp.arvensis	Gew. Wiesen-Witwenblume	Jakobsen	20-30°C	6. Juli 2011	51	50	50	germination too little
15	Plantago lanceolata	Spitz-Wegerich	Jakobsen	20-30°C	6. Juli 2011	57	44	70	germination too little
16	Salvia pratensis	Wiesen-Salbei	Jakobsen	20-30°C	14. Juni 2011	64	36	50	germination too little

4 Modelling of the seed production

The general aim is assess the seed quality of important species. The seed production quantifications like community, site, meadow, climate, soil and management, species considered and the collection of fertile stems at seed maturity are described in the final report 4.1.

4.1 Phenological survey of the considered species

The phenological survey has been done using a BBCH scale and the additional information (important especially for herbs and legumes) how many percent of the plant are in which emerging stage. The BBCH code in general gives information about the morphological development and growing stage of plants. The code serves as scientific communication tool to answer questions of plant development and to give information about the optimal harvesting time

Table 14: BBCH-code

00-09	Germination, sprouting, bud development
10-19	Leaf development (main shoot)
20-29	Formation of side shoots / tillering
30-39	Stem elongation /shoot development (main shoot)
40-49	vegetative propagation / booting (main shoot)
50-59	Inflorescence emergence (main shoot) / heading
60-69	Flowering (main shoot)
70-79	Development of fruit
80-89	Ripening or maturity of fruit and seed
90-99	Senescence, beginning of dormancy

Just to look at the 1x1m plots at the Arrhenatherion site “Welser Heide” was not useful, as on those small plots not all considered species could be found. So instead of the detailed survey just on the three 1x1m plots, the phenological survey has been done by taking a big overview around the not-treated plots to assess the BBCH Scale. The assessment has been done in 10 days interval beginning from mid of April to end of July. After the first cut the assessment has stopped.

4.1.1 Results Phenological survey Welser Heide 2010

The following Tables (2-5) show the BBCH Scale and the additional percentage values to have better notes of the emerging stage.

Table 15: BBCH Scale modified: grasses Welser Haide 2010 I

Date												
	Code of phenological stage	0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	0	13
04. Mai	Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	0	37
18. Mai	Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	0	51
28. Mai	Arrhenatherum elatius	0	0	0	0	0	50	0	0	0	0	56
06. Jun	Arrhenatherum elatius	0	0	0	0	0	0	100	0	0	0	61
16. Jun	Arrhenatherum elatius	0	0	0	0	0	0	0	100	0	0	71
26. Jun	Arrhenatherum elatius	0	0	0	0	0	0	0	0	100	0	88
06. Jul	Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	100	95
16. Jul	Arrhenatherum elatius	0	0	0	0	0	0	0	0	0	100	99
		0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Avenula pubescens	0	0	0	0	0	0	0	0	0	0	13
04. Mai	Avenula pubescens	0	0	0	0	0	0	0	0	0	0	58
18. Mai	Avenula pubescens	0	0	0	0	0	100	0	0	0	0	59
28. Mai	Avenula pubescens	0	0	0	0	0	90	10	0	0	0	67
06. Jun	Avenula pubescens	0	0	0	0	0	0	60	40	0	0	67
16. Jun	Avenula pubescens	0	0	0	0	0	0	0	100	0	0	77
26. Jun	Avenula pubescens	0	0	0	0	0	0	0	0	100	0	88
06. Jul	Avenula pubescens	0	0	0	0	0	0	0	0	0	100	99
16. Jul	Avenula pubescens	0	0	0	0	0	0	0	0	0	100	99
		0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Bromus erectus	0	0	0	0	0	0	0	0	0	0	13
04. Mai	Bromus erectus	0	0	0	0	0	0	0	0	0	0	50
18. Mai	Bromus erectus	0	0	0	0	0	0	0	0	0	0	57
28. Mai	Bromus erectus	0	0	0	0	0	100	0	0	0	0	59
06. Jun	Bromus erectus	0	0	0	0	0	10	90	0	0	0	67
16. Jun	Bromus erectus	0	0	0	0	0	0	0	100	0	0	81
26. Jun	Bromus erectus	0	0	0	0	0	0	0	0	100	0	84
06. Jul	Bromus erectus	0	0	0	0	0	0	0	0	0	100	95
16. Jul	Bromus erectus	0	0	0	0	0	0	0	0	0	100	99
		0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Dactylis glomerata	0	0	0	0	0	0	0	0	0	0	13
04. Mai	Dactylis glomerata	0	0	0	0	0	0	0	0	0	0	30
18. Mai	Dactylis glomerata	0	0	0	0	0	100	0	0	0	0	59
28. Mai	Dactylis glomerata	0	0	0	0	0	100	0	0	0	0	59
06. Jun	Dactylis glomerata	0	0	0	0	0	10	90	0	0	0	67
16. Jun	Dactylis glomerata	0	0	0	0	0	0	20	80	0	0	71
26. Jun	Dactylis glomerata	0	0	0	0	0	0	0	0	100	0	84
06. Jul	Dactylis glomerata	0	0	0	0	0	0	0	0	0	100	95
16. Jul	Dactylis glomerata	0	0	0	0	0	0	0	0	0	100	97
		0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Festuca pratensis	0	0	0	0	0	0	0	0	0	0	13
04. Mai	Festuca pratensis	0	0	0	0	0	0	0	0	0	0	31
18. Mai	Festuca pratensis	0	0	0	0	0	0	0	0	0	0	57
28. Mai	Festuca pratensis	0	0	0	0	0	100	0	0	0	0	59
06. Jun	Festuca pratensis	0	0	0	0	0	10	90	0	0	0	67
16. Jun	Festuca pratensis	0	0	0	0	0	0	20	80	0	0	79
26. Jun	Festuca pratensis	0	0	0	0	0	0	0	0	100	0	89
06. Jul	Festuca pratensis	0	0	0	0	0	0	0	0	0	100	95
16. Jul	Festuca pratensis	0	0	0	0	0	0	0	0	0	100	99
		0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Festuca rupicola	0	0	0	0	0	0	0	0	0	0	13
04. Mai	Festuca rupicola	0	0	0	0	0	0	0	0	0	0	59
18. Mai	Festuca rupicola	0	0	0	0	0	100	0	0	0	0	59
28. Mai	Festuca rupicola	0	0	0	0	0	100	0	0	0	0	65
06. Jun	Festuca rupicola	0	0	0	0	0	0	90	10	0	0	71
16. Jun	Festuca rupicola	0	0	0	0	0	0	0	100	0	0	79
26. Jun	Festuca rupicola	0	0	0	0	0	0	0	0	100	0	88
06. Jul	Festuca rupicola	0	0	0	0	0	0	0	0	0	100	98
16. Jul	Festuca rupicola	0	0	0	0	0	0	0	0	0	100	99
		0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Poa pratensis	0	0	0	0	0	0	0	0	0	0	14
04. Mai	Poa pratensis	0	0	0	0	0	0	0	0	0	0	57
18. Mai	Poa pratensis	0	0	0	0	0	100	0	0	0	0	59
28. Mai	Poa pratensis	0	0	0	0	0	100	0	0	0	0	65
06. Jun	Poa pratensis	0	0	0	0	0	10	90	0	0	0	67
16. Jun	Poa pratensis	0	0	0	0	0	0	0	100	0	0	81
26. Jun	Poa pratensis	0	0	0	0	0	0	0	0	100	0	88
06. Jul	Poa pratensis	0	0	0	0	0	0	0	0	0	100	98
16. Jul	Poa pratensis	0	0	0	0	0	0	0	0	0	100	99
		0	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Trisetum flavescens	0	0	0	0	0	0	0	0	0	0	
04. Mai	Trisetum flavescens	0	0	0	0	0	0	0	0	0	0	
18. Mai	Trisetum flavescens	0	0	0	0	0	10	0	0	0	0	51
28. Mai	Trisetum flavescens	0	0	0	0	0	0	100	0	0	0	59
06. Jun	Trisetum flavescens	0	0	0	0	0	0	0	100	0	0	59
16. Jun	Trisetum flavescens	0	0	0	0	0	0	0	100	0	0	69
26. Jun	Trisetum flavescens	0	0	0	0	0	0	0	0	100	0	88
06. Jul	Trisetum flavescens	0	0	0	0	0	0	0	0	0	100	97
16. Jul	Trisetum flavescens	0	0	0	0	0	0	0	0	0	100	98

Table 16: BBCH Scale modified: leguminosae and forbs Welser Heide 2010 II

20. Apr	Anthyllis vulneraria	0	0	0	0	0	0	0	0	0	0		14
04. Mai	Anthyllis vulneraria	0	0	0	0	0	0	0	0	0	0		50
18. Mai	Anthyllis vulneraria	0	0	0	0	0	100	0	0	0	0		56
28. Mai	Anthyllis vulneraria	0	0	0	0	0	10	40	50	0	0		66
06. Jun	Anthyllis vulneraria	0	0	0	0	0	0	60	40	0	0		74
16. Jun	Anthyllis vulneraria	0	0	0	0	0	0	10	90	0	0		79
26. Jun	Anthyllis vulneraria	0	0	0	0	0	0	0	0	100	0		81
06. Jul	Anthyllis vulneraria	0	0	0	0	0	0	0	0	0	100		95
16. Jul	Anthyllis vulneraria	0	0	0	0	0	0	0	0	0	100		98
		0	1	2	3	4	5	6	7	8	9		BBCH
20. Apr	Medicago lupulina	0	0	0	0	0	0	0	0	0	0		14
04. Mai	Medicago lupulina	0	0	0	0	0	0	0	0	0	0		43
18. Mai	Medicago lupulina	0	0	0	0	0	90	10	0	0	0		61
28. Mai	Medicago lupulina	0	0	0	0	0	60	30	10	0	0		64
06. Jun	Medicago lupulina	0	0	0	0	0	0	90	10	0	0		69
16. Jun	Medicago lupulina	0	0	0	0	0	0	80	20	0	0		69
26. Jun	Medicago lupulina	0	0	0	0	0	0	60	40	0	0		78
06. Jul	Medicago lupulina	0	0	0	0	0	0	50	50	0	0		83
16. Jul	Medicago lupulina	0	0	0	0	0	0	10	90	0	0		89
		0	1	2	3	4	5	6	7	8	9		BBCH
20. Apr	Trifolium pratense	0	0	0	0	0	0	0	0	0	0		16
04. Mai	Trifolium pratense	0	0	0	0	0	0	0	0	0	0		43
18. Mai	Trifolium pratense	0	0	0	0	0	90	10	0	0	0		61
28. Mai	Trifolium pratense	0	0	0	0	0	40	30	10	0	0		65
06. Jun	Trifolium pratense	0	0	0	0	0	0	90	10	0	0		71
16. Jun	Trifolium pratense	0	0	0	0	0	0	30	70	0	0		79
26. Jun	Trifolium pratense	0	0	0	0	0	0	30	70	0	0		80
06. Jul	Trifolium pratense	0	0	0	0	0	0	10	45	45	0		84
16. Jul	Trifolium pratense	0	0	0	0	0	0	10	30	30	30		89
		0	1	2	3	4	5	6	7	8	9		BBCH
20. Apr	Dianthus carhusianorum	0	0	0	0	0	0	0	0	0	0		12
04. Mai	Dianthus carhusianorum	0	0	0	0	0	0	0	0	0	0		48
18. Mai	Dianthus carhusianorum	0	0	0	0	0	90	10	0	0	0		61
28. Mai	Dianthus carhusianorum	0	0	0	0	0	70	30	0	0	0		63
06. Jun	Dianthus carhusianorum	0	0	0	0	0	70	20	10	0	0		71
16. Jun	Dianthus carhusianorum	0	0	0	0	0	70	20	10	0	0		71
26. Jun	Dianthus carhusianorum	0	0	0	0	0	40	40	20	0	0		78
06. Jul	Dianthus carhusianorum	0	0	0	0	0	0	30	70	0	0		83
16. Jul	Dianthus carhusianorum	0	0	0	0	0	0	20	80	0	0		83
		0	1	2	3	4	5	6	7	8	9		BBCH
20. Apr	Gallium album	0	0	0	0	0	0	0	0	0	0		14
04. Mai	Gallium album	0	0	0	0	0	0	0	0	0	0		51
18. Mai	Gallium album	0	0	0	0	0	90	10	0	0	0		59
28. Mai	Gallium album	0	0	0	0	0	80	20	0	0	0		61
06. Jun	Gallium album	0	0	0	0	0	80	10	10	0	0		65
16. Jun	Gallium album	0	0	0	0	0	70	20	10	0	0		69
26. Jun	Gallium album	0	0	0	0	0	40	40	20	0	0		75
06. Jul	Gallium album	0	0	0	0	0	0	30	70	0	0		87
16. Jul	Gallium album	0	0	0	0	0	0	20	80	0	0		87
		0	1	2	3	4	5	6	7	8	9		BBCH
20. Apr	Knautia arvensis	0	0	0	0	0	0	0	0	0	0		18
04. Mai	Knautia arvensis	0	0	0	0	0	0	0	0	0	0		49
18. Mai	Knautia arvensis	0	0	0	0	0	0	0	0	0	0		55
28. Mai	Knautia arvensis	0	0	0	0	0	0	0	0	0	0		65
06. Jun	Knautia arvensis	0	0	0	0	0	50	50	0	0	0		71
16. Jun	Knautia arvensis	0	0	0	0	0	50	40	10	0	0		74
26. Jun	Knautia arvensis	0	0	0	0	0	30	40	30	0	0		81
06. Jul	Knautia arvensis	0	0	0	0	0	0	20	80	0	0		88
16. Jul	Knautia arvensis	0	0	0	0	0	0	20	80	0	0		88
		0	1	2	3	4	5	6	7	8	9		BBCH
20. Apr	Plantago lanceolata	0	0	0	0	0	0	0	0	0	0		14
04. Mai	Plantago lanceolata	0	0	0	0	0	0	0	0	0	0		41
18. Mai	Plantago lanceolata	0	0	0	0	0	0	0	0	0	0		49
28. Mai	Plantago lanceolata	0	0	0	0	0	0	0	0	0	0		49
06. Jun	Plantago lanceolata	0	0	0	0	0	90	10	0	0	0		61
16. Jun	Plantago lanceolata	0	0	0	0	0	0	20	80	0	0		72
26. Jun	Plantago lanceolata	0	0	0	0	0	0	10	90	0	0		81
06. Jul	Plantago lanceolata	0	0	0	0	0	0	10	40	30	20		83
16. Jul	Plantago lanceolata	0	0	0	0	0	0	10	25	25	40		89
		0	1	2	3	4	5	6	7	8	9		BBCH
20. Apr	Salvia pratensis	0	0	0	0	0	0	0	0	0	0		14
04. Mai	Salvia pratensis	0	0	0	0	0	0	0	0	0	0		59
18. Mai	Salvia pratensis	0	0	0	0	0	40	60	0	0	0		65
28. Mai	Salvia pratensis	0	0	0	0	0	20	70	10	0	0		68
06. Jun	Salvia pratensis	0	0	0	0	0	0	60	40	0	0		74
16. Jun	Salvia pratensis	0	0	0	0	0	0	10	90	0	0		81
26. Jun	Salvia pratensis	0	0	0	0	0	0	0	0	100	0		90
06. Jul	Salvia pratensis	0	0	0	0	0	0	0	0	0	100		97
16. Jul	Salvia pratensis	0	0	0	0	0	0	0	0	0	100		99

4.1.2 Results Phenological survey Welser Heide 2011

Table 17: BBCH Scale modified: leguminosae and forbs Welser Heide 2011 II

Date	de of phenological stage				1						
	Glatthafer	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Arrhenatherum elatius	100	0	0	0	0	0	0	0	0	13
03. Mai	Arrhenatherum elatius	0	0	100	0	0	0	0	0	0	37
15. Mai	Arrhenatherum elatius	0	0	0	30	70	0	0	0	0	53
23. Mai	Arrhenatherum elatius	0	0	0	0	80	20	0	0	0	61
01. Jun	Arrhenatherum elatius	0	0	0	0	30	70	0	0	0	67
09. Jun	Arrhenatherum elatius	0	0	0	0	0	0	100	0	0	77
13. Jun	Arrhenatherum elatius	0	0	0	0	0	0	0	100	0	80
23. Jun	Arrhenatherum elatius	0	0	0	0	0	0	0	50	50	93
05. Jul	Arrhenatherum elatius	0	0	0	0	0	0	0	0	100	95
	Flaumhafer	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Avenula pubescens	100	0	0	0	0	0	0	0	0	14
03. Mai	Avenula pubescens	0	0	0	0	100	0	0	0	0	58
15. Mai	Avenula pubescens	0	0	0	0	70	30	0	0	0	61
23. Mai	Avenula pubescens	0	0	0	0	0	100	0	0	0	63
01. Jun	Avenula pubescens	0	0	0	0	0	0	100	0	0	79
09. Jun	Avenula pubescens	0	0	0	0	0	0	0	90	10	89
13. Jun	Avenula pubescens	0	0	0	0	0	0	0	10	90	95
23. Jun	Avenula pubescens	0	0	0	0	0	0	0	0	100	98
05. Jul	Avenula pubescens	0	0	0	0	0	0	0	0	100	99
	Aufrechte Trespe	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Bromus erectus	100	0	0	0	0	0	0	0	0	13
03. Mai	Bromus erectus	0	0	0	10	90	0	0	0	0	53
15. Mai	Bromus erectus	0	0	0	0	100	0	0	0	0	58
23. Mai	Bromus erectus	0	0	0	0	60	40	0	0	0	61
01. Jun	Bromus erectus	0	0	0	0	0	100	0	0	0	69
09. Jun	Bromus erectus	0	0	0	0	0	0	100	0	0	73
13. Jun	Bromus erectus	0	0	0	0	0	0	0	100	0	80
23. Jun	Bromus erectus	0	0	0	0	0	0	0	100	0	89
05. Jul	Bromus erectus	0	0	0	0	0	0	0	80	20	92
	Knaulgras	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Dactylis glomerata	100	0	0	0	0	0	0	0	0	13
03. Mai	Dactylis glomerata	0	0	100	0	0	0	0	0	0	33
15. Mai	Dactylis glomerata	0	0	0	0	100	0	0	0	0	59
23. Mai	Dactylis glomerata	0	0	0	0	40	60	0	0	0	65
01. Jun	Dactylis glomerata	0	0	0	0	30	70	0	0	0	69
09. Jun	Dactylis glomerata	0	0	0	0	0	30	70	0	0	71
13. Jun	Dactylis glomerata	0	0	0	0	0	10	90	0	0	79
23. Jun	Dactylis glomerata	0	0	0	0	0	0	0	100	0	89
05. Jul	Dactylis glomerata	0	0	0	0	0	0	0	40	60	91
	Wiesenschwingel	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Festuca pratensis	100	0	0	0	0	0	0	0	0	12
03. Mai	Festuca pratensis	0	0	100	0	0	0	0	0	0	31
15. Mai	Festuca pratensis	0	0	0	50	50	0	0	0	0	57
23. Mai	Festuca pratensis	0	0	0	0	100	0	0	0	0	59
01. Jun	Festuca pratensis	0	0	0	0	10	90	0	0	0	67
09. Jun	Festuca pratensis	0	0	0	0	0	0	100	0	0	71
13. Jun	Festuca pratensis	0	0	0	0	0	0	100	0	0	77
23. Jun	Festuca pratensis	0	0	0	0	0	0	0	100	0	87
05. Jul	Festuca pratensis	0	0	0	0	0	0	0	20	80	92
	Furchenschwingel	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Festuca rupicola	100	0	0	0	0	0	0	0	0	12
03. Mai	Festuca rupicola	0		0	0	100	0	0	0	0	57
15. Mai	Festuca rupicola	0	0	0	0	100	0	0	0	0	59
23. Mai	Festuca rupicola	0	0	0	0	90	10	0	0	0	60
01. Jun	Festuca rupicola	0	0	0	0	0	0	100	0	0	73
09. Jun	Festuca rupicola	0	0	0	0	0	0	100	0	0	73
13. Jun	Festuca rupicola	0	0	0	0	0	0	0	100	0	81
23. Jun	Festuca rupicola	0	0	0	0	0	0	0	0	100	92
05. Jul	Festuca rupicola	0	0	0	0	0	0	0	0	100	98
	Wiesenrispe	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Poa pratensis	100	0	0	0	0	0	0	0	0	13
03. Mai	Poa pratensis	0	0	0	0	100	0	0	0	0	59
15. Mai	Poa pratensis	0	0	0	0	40	60	0	0	0	61
23. Mai	Poa pratensis	0	0	0	0	10	90	0	0	0	66
01. Jun	Poa pratensis	0	0	0	0	0	0	100	0	0	71
09. Jun	Poa pratensis	0	0	0	0	0	0	0	100	0	89
13. Jun	Poa pratensis	0	0	0	0	0	0	0	0	100	92
23. Jun	Poa pratensis	0	0	0	0	0	0	0	0	100	95
05. Jul	Poa pratensis	0	0	0	0	0	0	0	0	100	99
	Goldhafer	1	2	3	4	5	6	7	8	9	BBC
20. Apr	Trisetum flavescens	100	0	0	0	0	0	0	0	0	12
03. Mai	Trisetum flavescens	0	0	100	0	0	0	0	0	0	31
15. Mai	Trisetum flavescens	0	0	0	0	100	0	0	0	0	58
23. Mai	Trisetum flavescens	0	0	0	0	20	80	0	0	0	60
01. Jun	Trisetum flavescens	0	0	0	0	0	20	80	0	0	69
09. Jun	Trisetum flavescens	0	0	0	0	0	0	100	0	0	71
13. Jun	Trisetum flavescens	0	0	0	0	0	0	20	100	0	80
23. Jun	Trisetum flavescens	0	0	0	0	0	0	0	100	0	89
05. Jul	Trisetum flavescens	0	0	0	0	0	0	0	0	100	95

Table 18: BBCH Scale modified: leguminosae and forbs Welser Heide 2011 II

	Echter Wundklee	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Anthyllis vulneraria	100	0	0	0	0	0	0	0	0	14
03. Mai	Anthyllis vulneraria	0	0	0	0	100	0	0	0	0	59
15. Mai	Anthyllis vulneraria	0	0	0	0	50	50	0	0	0	65
23. Mai	Anthyllis vulneraria	0	0	0	0	0	100	0	0	0	68
01. Jun	Anthyllis vulneraria	0	0	0	0	0	90	10	0	0	69
09. Jun	Anthyllis vulneraria	0	0	0	0	0	50	50	0	0	71
13. Jun	Anthyllis vulneraria	0	0	0	0	0	35	35	20	10	75
23. Jun	Anthyllis vulneraria	0	0	0	0	0	30	20	20	30	78
05. Jul	Anthyllis vulneraria	0	0	0	0	0	10	20	40	30	87
	Feldklee	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Trifolium campestre	100	0	0	0	0	0	0	0	0	14
03. Mai	Trifolium campestre	0	0	0	100	0	0	0	0	0	55
15. Mai	Trifolium campestre	0	0	0	60	40	0	0	0	0	59
23. Mai	Trifolium campestre	0	0	0	0	70	30	0	0	0	60
01. Jun	Trifolium campestre	0	0	0	0	0	30	70	0	0	69
09. Jun	Trifolium campestre	0	0	0	0	0	10	90	0	0	73
13. Jun	Trifolium campestre	0	0	0	0	0	45	45	10	0	74
23. Jun	Trifolium campestre	0	0	0	0	0	20	70	10	0	77
05. Jul	Trifolium campestre	0	0	0	0	0	20	40	40	0	81
	Rot-Klee	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Trifolium pratense	100	0	0	0	0	0	0	0	0	18
03. Mai	Trifolium pratense	0	0	100	0	0	0	0	0	0	38
15. Mai	Trifolium pratense	0	0	0	100	0	0	0	0	0	48
23. Mai	Trifolium pratense	0	0	0	0	100	0	0	0	0	58
01. Jun	Trifolium pratense	0	0	0	0	0	80	20	0	0	68
09. Jun	Trifolium pratense	0	0	0	0	0	60	40	0	0	72
13. Jun	Trifolium pratense	0	0	0	0	0	50	25	25	0	75
23. Jun	Trifolium pratense	0	0	0	0	0	25	25	25	25	77
05. Jul	Trifolium pratense	0	0	0	0	0	0	10	50	40	81
	Eigentl.Karthäuser Nel	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Dianthus carhusianoru	100	0	0	0	0	0	0	0	0	18
03. Mai	Dianthus carhusianoru	0	0	0	100	0	0	0	0	0	48
15. Mai	Dianthus carhusianoru	0	0	0	0	90	10	0	0	0	61
23. Mai	Dianthus carhusianoru	0	0	0	0	70	30	0	0	0	63
01. Jun	Dianthus carhusianoru	0	0	0	0	10	80	10	0	0	65
09. Jun	Dianthus carhusianoru	0	0	0	0	0	20	80	0	0	71
13. Jun	Dianthus carhusianoru	0	0	0	0	0	40	30	20	10	72
23. Jun	Dianthus carhusianoru	0	0	0	0	0	30	30	25	25	77
05. Jul	Dianthus carhusianoru	0	0	0	0	0	25	30	20	25	81
	Großes Wiesen-Labkr	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Gallium album	100	0	0	0	0	0	0	0	0	19
03. Mai	Gallium album	0	0	0	0	100	0	0	0	0	51
15. Mai	Gallium album	0	0	0	0	100	0	0	0	0	53
23. Mai	Gallium album	0	0	0	0	0	100	0	0	0	63
01. Jun	Gallium album	0	0	0	0	0	100	0	0	0	65
09. Jun	Gallium album	0	0	0	0	0	50	50	0	0	71
13. Jun	Gallium album	0	0	0	0	0	30	50	20	0	72
23. Jun	Gallium album	0	0	0	0	0	50	30	20	0	77
05. Jul	Gallium album	0	0	0	0	0	40	20	20	20	78
	Witwenblume	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Knautia arvensis	100	0	0	0	0	0	0	0	0	18
03. Mai	Knautia arvensis	0	0	0	100	0	0	0	0	0	43
15. Mai	Knautia arvensis	0	0	0	0	80	20	0	0	0	62
23. Mai	Knautia arvensis	0	0	0	0	50	35	15	0	0	66
01. Jun	Knautia arvensis	0	0	0	0	25	50	25	0	0	68
09. Jun	Knautia arvensis	0	0	0	0	10	50	40	0	0	69
13. Jun	Knautia arvensis	0	0	0	0	0	30	40	20	10	72
23. Jun	Knautia arvensis	0	0	0	0	0	20	30	20	20	75
05. Jul	Knautia arvensis	0	0	0	0	0	20	20	20	40	89
	Spitzwegerich	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Plantago lanceolata	100	0	0	0	0	0	0	0	0	16
03. Mai	Plantago lanceolata	0	0	100	0	0	0	0	0	0	30
15. Mai	Plantago lanceolata	0	0	0	100	0	0	0	0	0	46
23. Mai	Plantago lanceolata	0	0	0	100	0	0	0	0	0	49
01. Jun	Plantago lanceolata	0	0	0	0	90	10	0	0	0	61
09. Jun	Plantago lanceolata	0	0	0	0	0	60	40	0	0	69
13. Jun	Plantago lanceolata	0	0	0	0	0	50	50	0	0	69
23. Jun	Plantago lanceolata	0	0	0	0	0	20	80	0	0	75
05. Jul	Plantago lanceolata	0	0	0	0	0	10	40	40	10	78
	Wiesen-Salbei	1	2	3	4	5	6	7	8	9	BBCH
20. Apr	Salvia pratensis	100	0	0	0	0	0	0	0	0	15
03. Mai	Salvia pratensis	0	0	0	0	100	0	0	0	0	57
15. Mai	Salvia pratensis	0	0	0	0	70	30	0	0	0	63
23. Mai	Salvia pratensis	0	0	0	0	0	100	0	0	0	65
01. Jun	Salvia pratensis	0	0	0	0	0	20	80	0	0	71
09. Jun	Salvia pratensis	0	0	0	0	0	10	80	10	0	71
13. Jun	Salvia pratensis	0	0	0	0	0	20	30	50	10	82
23. Jun	Salvia pratensis	0	0	0	0	0	20	15	15	50	89
05. Jul	Salvia pratensis	0	0	0	0	0	10	5	5	80	93

The results of the phenological data demonstrate that not all the species are ripe at the same time and that it is important, if possible, to harvest at different times, in general the grasses carry the ripe seeds earlier than the leguminosae and the forbs (Hölzel and Otte, 2003).

4.2 Consideration of seed production and quality

The results obtained from Action 4.1 and 4.2 showed that in 57 % of the cases germination was too low according to the ISTA rules (ISTA, 2011). Four species do not even reach a germination capacity of 30%.

4.3 Consideration of the fertile stems density

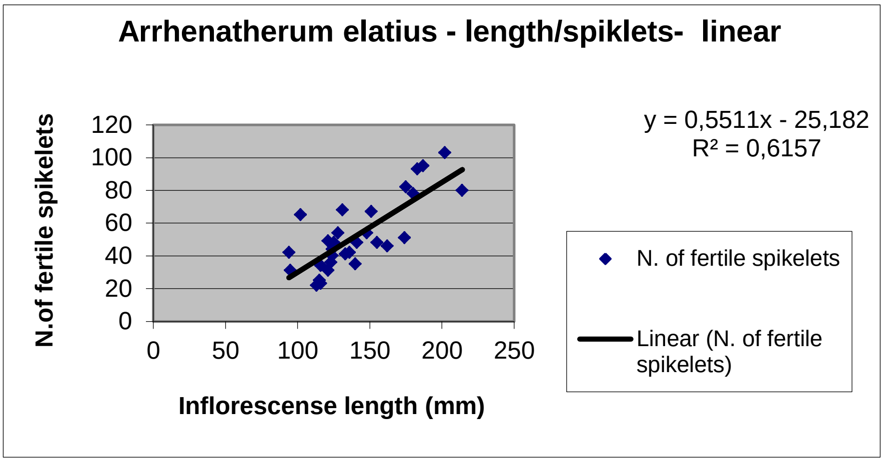
The results obtained from Action 4.1 show how many seeds m^{-2} could be harvested at the date of collection. This result gives an impression of how much seed could have been collected at the whole site. A change within the fertile stems density between 2010 and 2011 is mostly due to the completely different weather conditions in both years.

4.4 Construction of the model

The models we tried to work out with linear- and exponential regressions. The regression presents the correlation between a scalar variable Y and one or more explanatory variables denoted X. In linear regression, data are modelled using linear functions, in exponential regressions data are modelled using the logarithm. Further the correlation coefficient gives some information about the goodness of fit of a model. The correlation coefficient is a measure of the correlation between two variables X and Y, in our case giving a value between 0 and 1. For example 1.0 indicates that the regression line perfectly fits the data.

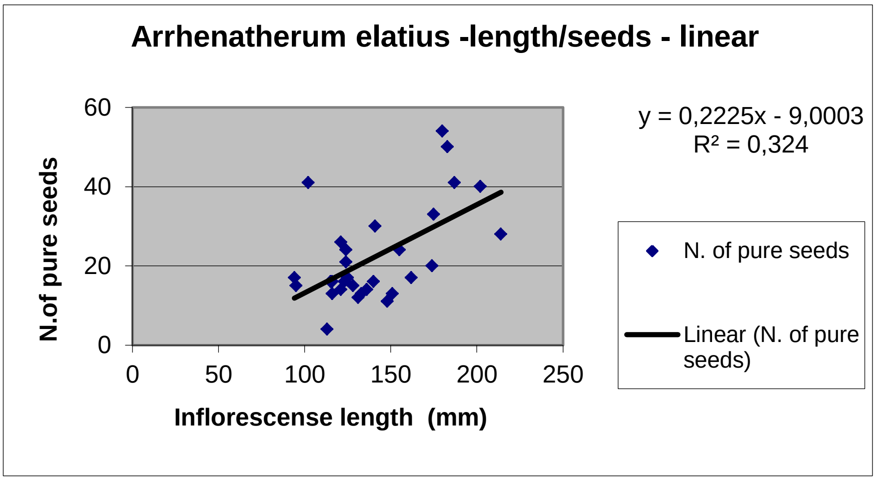
Figure 1 shows the linear regression of the data obtained from *Arrhenatherum elatius* in 2011. The correlation coefficient with 0.61 is high. This means that only 61% of our data can be showed with the calculated regression.

Figure 10*: Arrhenatherum elatius* length/spiklets – linear regression



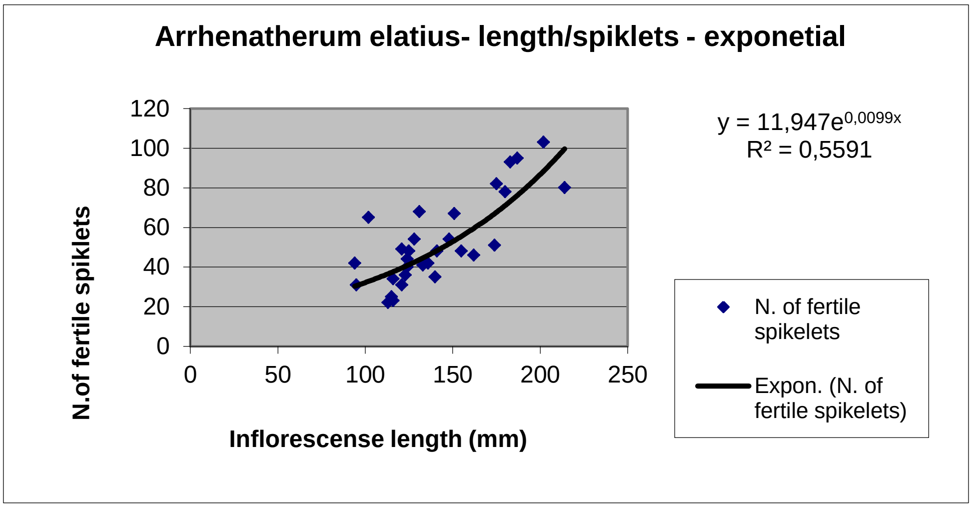
The correlation of length and seeds shown in Figure 2 is lower. In this case the correlation coefficient is just 0,32. This is probably due to the fact that in nature not all seed is falling out at the same time. Some plants have already lost a lot and some have not lost any seeds at the date of harvesting. This difference now disrupts the statistical analysis.

Figure 11: *Arrhenatherum elatius* length/seeds – linear regression



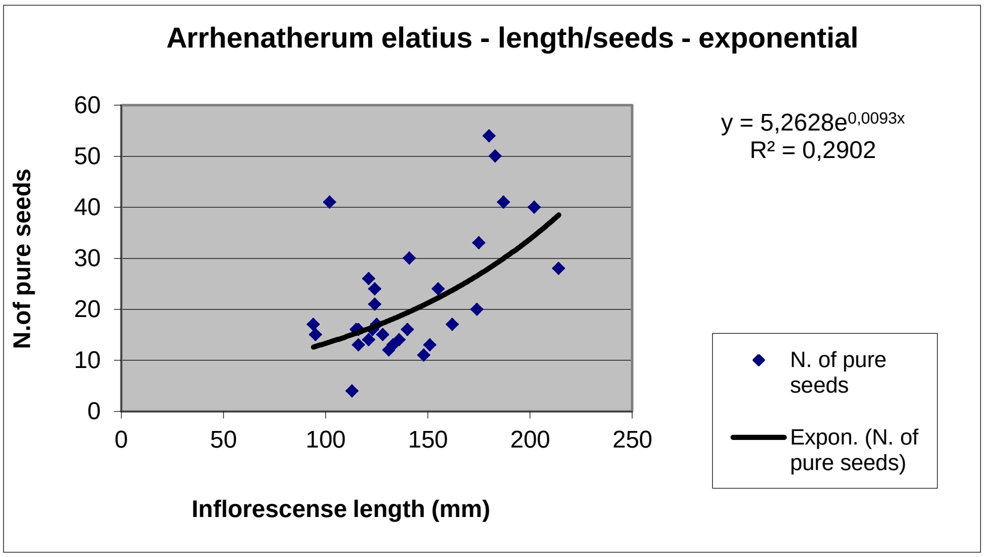
The results of the correlation coefficient in exponential regressions for *Arrenatherum elatius* is not as good as with the linear regression (Figure 3). This means that in the case of *Arrenatherum elatius* the exponential regression shows better results concerning correlation than the linear regression.

Figure 12: *Arrhenatherum elatius* length/spiklets – exponential regression



Similar to the linear regression the correlation between the inflorescence length and the fertile spikelets shows better results than the correlation between the inflorescence length and the seed.

Figure 13: *Arrhenatherum elatius* length/seeds – exponential regression



5 Conclusion

The potential and the real seed production of single fertile stems of the important species of the donor site Welser Heide does not leave really a correlation, because the ripe seeds have fallen out from the fertile stems from different species.

The value - seeds per millimetre offers a simple way to estimate the seed yield of a specific site by extrapolating the results of measuring the size of inflorescence in a testing plot to the whole site.

The poor form of the Arrhenatherion donor site Welser Heide produces a low density of fertile stems in comparison to the results of Scotton et al. (2009).

At the harvesting time almost all grasses were ripe. Most herbs reach maturity later because they have a longer ripening time. To collect all species two harvesting times would be recommendable.
The thousand seed weight (TSW) of all species differs between the years 2010 and 2011; some species had a higher TSW in the year 2010, some in the year 2011. Also the seed size has differences over the years, but there is no trend evident.
A high amount of species (nearby 2/3) do not reach the germination capacity according to the International rules of seed testing (ISTA 2011) and the differences between the years show no trend.

Project partner 2 is combining and processing the data described under the points 2.1, 2.2 and 2.3. The amount of mature seed present for each species can be estimated through phenological surveys. The statistics with the linear- and exponential regressions was made from the data to estimate the standing seed yield (model).

The model will get tested in future. For this testing four 50x50cm plots will be established. For each species on the plot the phenological data according to the modified BBCH Scale will be reviewed. At the day of harvesting all fertile stems will be collected and analysed for their size and seed amounts present on the collected fertile stems. The standing seed yield will be calculated with the model to compare the model output with the amounts obtained from the collected fertile stems.

The results of the phonological data demonstrate that not all the species are ripe at the same time and that it is important, wherever possible to harvest at different times, in general the grasses produce the ripe seeds earlier than the leguminosae and the forbs.

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