EGRO-project Summer 1995

Part I: Soil nutrient input effects on seed viability

Part II: Impact of canopy structure on seed germination and survival of selected semi-natural grassland species

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Report of a six months project in Great Britain

by
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What would the world be, once bereft
Of wet and of wilderness? Let them be left,
O let them be left, wilderness and wet;
Long live the weeds and the wilderness yet.

(Gerard Manley, Seasons of Dartmoor, 1994)

Contents

General Introduction

This is a report of a six month project in the summer of 1995 at the Institute of Grassland and Environmental Research (IGER)/ North Wyke Station, Devon, Great Britain. The project is part of the fulfilment of a degree in biology at the University of Groningen (RUG, The Netherlands).

IGER

The Institute of Grassland and Environmental Research (IGER) is a research institute that carries out independent research in the public interest and in the interest of the agricultural industry. The scientific aims of the institute are to improve the efficiency and to increase the diversity of agricultural grasslands (IGER, 1993). The institute consists of four research stations, located all over the UK, of which North Wyke Research Station in Okehampton, Devon is one. The Ecology and Agronomy group of IGER's North Wyke research station has interest in alternative land use including agro-forestry and management of grasslands for floristic diversity. The ecology group of North Wyke is working together with the department of plant ecology from the University of Groningen (The Netherlands) on several tasks of the EC-project EGRO.

EC-project

The degradation of flora and vegetation in natural and semi-natural landscapes has become a matter of great concern. The problem affects the whole of western Europe as well as many other parts of the temperate world. This may be attributed to the dense population and the high level of technological development resulting in expanding towns, villages and industrial areas connected by a vast network of roads. Intensification of grassland management this century has resulted in enormous decreases in biological diversity within the farmed landscape (Baldock: see IGER, 1994). The question is: "Is there a way back from degraded grassland to species-rich grassland communities?". (Bakker, 1989)

The EC-project started in 1993 and is titled **"Extensive management of grassland, impact on conservation of biological resources and farm output" (E.G.R.O.)**. The following organizations are involved in this project:

- The Institute of Grassland and Environmental Research (Great Britain)
- Universite Catholique de Louvain (Belgium)
- Instituto Pirenaico de Ecologia (Spain)
- University of Groningen (The Netherlands)
- DLO-Centre for Agrobiological Research (The Netherlands)

The main objectives of the EGRO-project are to establish methods to increase and maintain biological resources, particularly plant diversity, in extensively managed grasslands and to measure the impact of these managements on farm output and livelihood. EGRO aims to identify the factors limiting re-establishment of biological resources in extensively managed agricultural grasslands. The objectives of the EGRO-project are transferred into different tasks to be worked out by the participants during the three years of the project.

Project summer 1995

During this summer task two and seven of the EGRO project have been carried out. Task two of EGRO is an experiment about the impact of high nutrient availability on the viability of seeds of grassland wild flower species in the seedbank. The results of this experiment are presented in part I of this report.
Task seven of EGRO is an experiment to identify the impact of differences in canopy structure on seed germination and establishment. The results of this experiment are presented in part II of this report.

PART I:

Soil nutrient input effects on seed viability

Contents

Abstract

To examine the effects of high nutrient input on seed viability, nylon mesh bags with seeds of selected semi-natural grassland species were buried on plots treated with N, P, K fertilizer at five sites in The Netherlands and Great Britain. Before burial a blank germination test in the laboratory took place. The fertilizing started in spring 1993 and will be repeated each year of the project. The seeds will be exhumed at each of four periods (year 1, 2, 4 and 8) and tested on their viability by means of germination. This year the first seed samples were exhumed and tested.

The results show that there are no significant differences in viability of the seeds between the different treatments within the species of a site and between the treatments within the sites. However, there are significant differences in germination percentages between the blank germination test and the exhumed seeds. There are also significant differences between the species within the treatments and within the sites. Statistical analysis also shows significant differences in germination of the seeds of the same species and origin between the sites.

1. Introduction

1.1 General

Intensification of grassland management throughout western Europe has resulted in enormous reduction in biological diversity within the farmed landscape. The decrease in floristic diversity in temperate grasslands is mainly influenced by soil nutrient availability (Grubb, 1987). The enhanced nutrient availability as a result of high fertilizer inputs is a major cause of low plant species diversity and a key-factor limiting the restoration of biological resources when extensification occurs (Bakker, 1989). However, experience has shown that de-intensification of farming practices by a reduction in fertilizer input and the adaptation of traditional managements, such as hay making, often fail to achieve a recovery in floristic diversity (IGER, 1994). Where plant species disappear from the vegetation but possible survive in the seed bank, buried seeds can play an important role in conservation and restoration management. Research has shown that wild flower species on de-intensified farm grassland often appear to be poorly represented in the soil seed bank (Ohrmann, 1994). This could be the result of a reduced survival of buried seed in the soil or a reduced seed rain due to a species-poor vegetation. Both are possible influenced by enhanced nutrient availability through former intensive management. Therefore it is important to identify the persistent components of species-rich grassland seed banks to understand the mechanisms by which they are lost or longevity of seeds declines. Further research is needed to identify the different factors which play an important role in successful establishment of the desired grassland species on agricultural improved sites.
This further research is done by different organizations working on the EC-project 'Extensive management of Grassland, impact on conservation of biological Resource and farm Output (E.G.R.O.)'.

1.2 Seed-burial project (Task 2)

Task two of EGRO is an experiment about the impact of high nutrient availability on the viability of seeds of grassland wild flower species in the seedbank. Seedbags with seeds of important plant species of species-rich grassland communities were buried at five different sites in Great Britain and The Netherlands. The sites each contain an experimental field which is subdivided into 25 plots which receive different fertilizer treatments (no fertilizer, Nitrate N, Phosphorus P and Potassium K) during the eight years of the seed-burial project. In March 1994 the seedbags were buried and will be exhumed at each of four periods (1, 2, 4 and 8 years after burial). The first seedbags are exhumed during this experiment (year 1) and are tested on viability by means of germination. Because of the differences in germination of the exhumed seeds and the amount of seeds which did

not germinate, the impact of different fertilizer treatments on the viability of buried seeds can be determined.
The objective of the seed-burial project is to establish the impact of high nitrogen, phosphorus and potassium availability on the longevity of seeds of grassland wild flower species. Fenner (1985) found that with an enhancing nutrient availability the amount of seeds that are viable will decline. Therefore the expectation of the seed burial project is that there will be significant differences in the viability of the seeds within the species from the same site (and between sites) which received different fertilizer treatments. Because this is the first year that the seedbags are exhumed and the third year of the fertilizer treatments, the expectation is that there will not yet be significant differences between the different treatments within the species.

2. Materials and Methods

2.1. General procedure

The semi-natural grassland species used in this experiment were chosen on the grounds of their seeds known to have a longevity of at least more than one year in the soil seedbank (Table 2.1) and them being key elements of the site flora. For practical reasons some species with a probably low longevity are included because of the availability of enough seeds and by lack of enough evidence for their longevity.

Table 2.1: Longevity of the seeds.

Species	Index *	Species	Index *
Anthoxantum odoratum	0.29	Lychnis flos-cuculi	0.56
Carex acutiformis	0.50	Pedicularis palustris	1.00
Carex curta	0.00	Potentilla erecta	0.43
Carex echinata	0.38	Potentilla palustris	0.13
Carex flacca	0.46	Ranunculus flammula	0.63
Carex hostiana	1.00	Scirpus sylvaticus	0.21
Carex nigra	0.19	Senecio aquatica	0.00
Crepis paludosa	0.00	Viola palustris	0.11
Filipendula ulmaria	0.11		

* Longevity Index: 0-0.49 = short lived, 0.50-1.00 = long lived (Derived from Thompson *et. al* (1996) in prep.).

Most of the seeds used, were collected in the summer of 1993 at the sites where the burial would take place. The sites where the seeds were collected consist of four sites in The Netherlands (NEG-sites) and one site in Great Britain (GB-site) (Table 2.3). The seeds of *Lychnis flos-cuculi* from the sites in The Netherlands which were collected at "Oude Molen" (NEG9 and NEG9D) and "Lange Sâne" (NEG10 and NEG11). Whereas the seeds of *Potentilla erecta* and *Lychnis flos-cuculi* for the Great Britain site were bought commercially. The seeds of *Filipendula ulmaria* for the Great Britain site were collected at the NEG9 sites in The Netherlands. The collected seeds were tested on viability and stored dark and cold (4° Celsius) with a relatively low air-humidity of 40-50 %. Fifty seeds per species were mixed with 20 cc. sterilized potting compost or sterilized Calthion soil and put into colour marked nylon bags (Table 2.3). The amount of seeds in the seedbags was counted by means of a machine, except the seeds of *Crepis paludosa* (NEG9 and NEG9D), *Carex curta* (NEG10), *Senecio aquatica* (NEG11), *Carex hostiana* (GB4) and *Carex flacca* (GB4) which were counted by hand. The calibration of the counting machine and the counting of the seeds by hand after washing is listed in table 2.2.

Table 2.2. The calibration of the counting machine. The mean germination percentages before washing (machine) and the mean germination percentages after washing (counting by hand) given with the standard error (± s.e.) and the sample size (N).

Species	Machine (± s.e.)	N	Hand (± s.e.)	N
Scirpus sylvaticus	56.4 (± 0.830)	22	50.1 (± 0.671)	75
Anthoxantum odoratum	56.7 (± 1.711)	11	49 (± 0.706)	39
Lychnis flos-cuculi *	57.7 (± 0.952)	22	50 (± 0.493)	76
Lychnis flos-cuculi @	57.5 (± 0.731)	11	48.4 (± 0.610)	77
Lychnis flos-cuculi +	56.2 (± 1.350)	22	44 (± 1.528)	39
Filipendula ulmaria	50.2 (± 0.456)	33	43.6 (± 0.478)	76
Viola palustris	53.8 (± 0.989)	11	51.7 (± 0.448)	37
Carex echinata	52.4 (± 0.834)	11	51.3 (± 0.471)	37
Pedicularis palustris	49.8 (± 0.672)	11	46.2 (± 0.715)	37
Carex nigra	52.4 (± 0.472)	11	48.8 (± 0.484)	34
Ranunculus flammula	52.3 (± 0.702)	11	40.4 (± 1.077)	38
Carex acutiformis	51.2 (± 0.596)	21	46.3 (± 0.486)	75
Potentilla erecta +	50.9 (± 0.620)	22	46.4 (± 0.570)	38
Potentilla palustris	49.2 (± 1.190)	11	48.8 (± 0.483)	38
Crepis paludosa	50	hand	48.6 (± 0.671)	37
Carex curta	50	hand	48.6 (± 0.580)	38
Senecio aquatica	50	hand	47.2 (± 0.478)	38
Carex hostiana +	unknown		47.4 (± 0.642)	38
Carex flacca +	unknown		37.8 (± 1.433)	38

* Seed from The Netherlands ("Oude Molen")
@ Seed from The Netherlands ("Lange Sâne")
\+ Seed from Great Britain

The seedbags were buried in February/March 1994 at about 5 cm. depth at the five different sites. Therefore in each site an experimental field is created from 20x20 meters which is subdivided into 25 plots of 2x2 meters (Figure 2.3 - 2.6). With a framework each plot is subdivided into 16 quadrates where the seedbags at random were buried in 10 of the 16 quadrates (Figure 2.1).

Figure 2.1: Burial frame (2x2 meter) used for the burial and exhumation of the seedbags, subdivided into 0.25x0.25 meter quadrates.

top left top right

1		2	
	3	4	5
	6	7	
8	9	10	

2 m. (height)

2 m. (width)

In total 10 replicates of 50 seeds of each species were buried within each treatment plot. The seedbags are inserted in the quadrates by lifting the sod with a spade and inserting the five bags in a fixed pattern.

In 1993, before the burial of the seedbags, the plots received the first fertilizer treatments: a zero fertilizer control (A), a nitrogen only (N), a phosphorus only (P), a potassium only (K) and a full NPK treatment (F) with the amounts of each nutrient applied together at the respective plot. There are four replicates of each treatment per site. In table 2.3 the species which were buried and the different treatments per site are listed.

The five remaining plots are soil nutrient availability plots (S-plots) which received no fertilizer and where no seedbags were buried (control without seedbags; Table 2.3).

Table 2.3: The different species per site with the different treatments. From the marked species the seedbags were filled with sterilized potting compost

Site	Treatments	Kg/ha.	Species
Desiccated Calthion (NEG9D)	N P K F (= NPK) A (= control with seed) S (= control without seed)	200 80 200 full - -	Lychnis flos-cuculi Scirpus sylvaticus Anthoxantum odoratum Filipendula ulmaria Carex acutiformis
Calthion (NEG9)	N P K F (= NPK) A (= control with seed) S (= control without seed)	200 80 200 full - -	Lychnis flos-cuculi Scirpus sylvaticus Crepis paludosa Filipendula ulmaria Carex acutiformis *
Caricion curto-nigrae (NEG10)	N P K F (= NPK) A (= control with seed) S (= control without seed)	200 80 200 full - -	Lychnis flos-cuculi Carex curta Carex echinata Viola palustris Potentilla palustris *
Magnocaricion (NEG11)	N P K F (= NPK) A (= control with seed) S (= control without seed)	200 80 200 full - -	Lychnis flos-cuculi Carex nigra Pedicularis palustris Senecio aquatica Ranunculus flammula *
Centaureo-Cynosuretum (GB4)	N P K F (NPK) A (= control with seed) S (= control without seed)	200 75 200 full - -	Lychnis flos-cuculi * Carex hostiana * Carex flacca * Potentilla erecta * Filipendula ulmaria *

The nutrients on the NEG-sites were applied at once as 'slow release grains' in spring 1993, 1994 and 1995 where as the nutrients in the GB4 site were applied as grains in four weekly periods to prevent burning of the herbage (Table 2.4). The nutrient treatment will be repeated each year of the seed-burial project.

Table 2.4. The amounts of nutrients applied at the GB4 site given per application period.

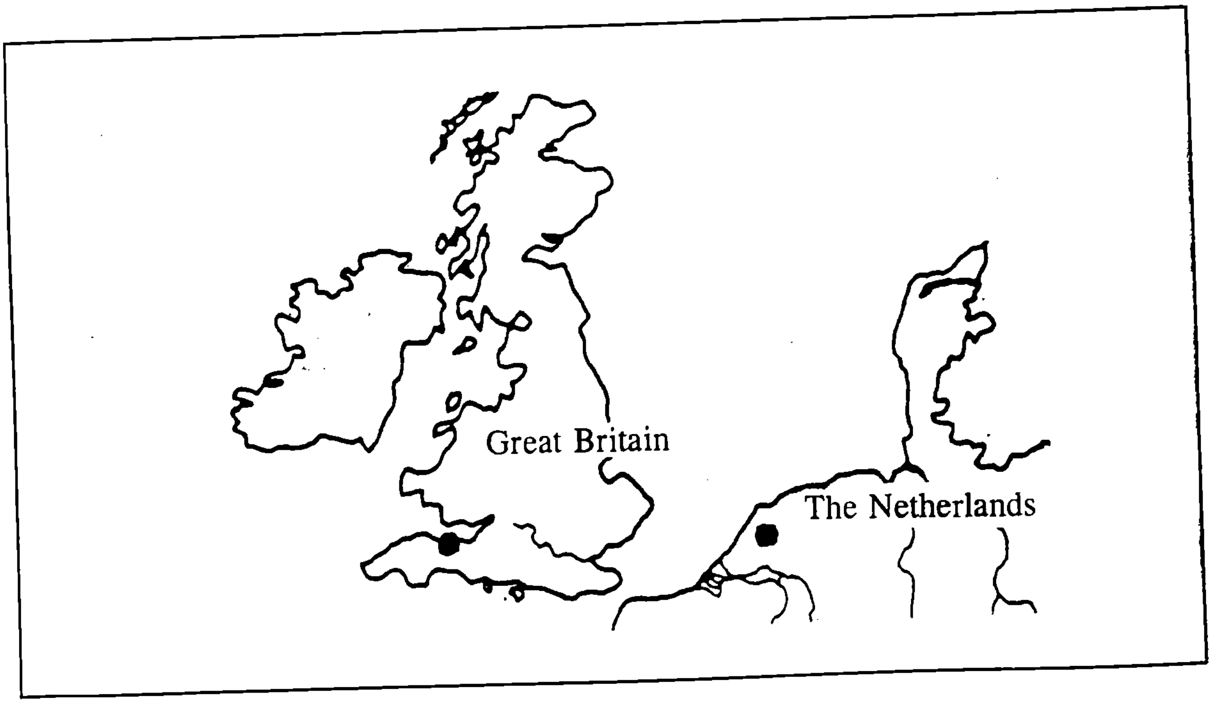
Period	Treatment N[1] (g/plot)	Treatment P[2] (g/plot)	Treatment K[3] (g/plot)	Treatment F (g/plot) N[1]	P[2]	K[3]
1	57.97	37.5	40.1	57.97	37.5	40.1
2	57.97	37.5	40.1	57.97	45.83	40.1
3	57.97	37.5	40.1	57.97	45.83	40.1
4	57.97	37.5	40.1	57.97	45.83	40.1

[1] Nitrate given as Nitram
[2] Phosphate given as Triple Superphosphate
[3] Potassium given as Muriate or Potash

2.2. Site description

The sites where the seeds were buried, consisted of two *Calthion palustris* communities, a *Caricion curto-nigrae* community, a *Magnocaricion* community and a *Centaureo-Cynosuretum* community (Den Held, 1989). The first four sites are situated in The Netherlands (Drenthe) and the last site in Great Britain (Somerset)(Figure 2.2).

Figure 2.2: The experimental fields situated in Great Britain (GB4) and The Netherlands (NEG9-NEG11).



The *Calthion palustris* community is divided by a ditch and consist of a higher situated desiccated part (NEG9D) and a lower situated part, still in a good hydrological condition (NEG9). A humic soil is overlaying the sandy subsoil within a deep seepage system with Calcium-enriched groundwater. The site is unfertilized for more then 20 years (EGRO, 1994) (Figure 2.3).

Figure 2.3: The desiccated Calthion seed burial site (a) and the Calthion seed burial site (b) with the different treatments per plot. The treatments are: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, S = Control without seedbags (no fertilizer).

a) Desiccated Calthion (NEG9D):

A 1	S 2	F 3	S 4	N 5	A 6	
K 7	S 8	S 9	N 10	P 11	N 12	
P 13	F 14	A 15	S 16	P 17	F 18	
P 19	K 20	F 21	A 22	K 23	K 24	N 25

b) Calthion (NEG9):

P 1	A 2	F 3	F 4	K 5	A 6	N 7	S 8	F 9
F 10	S 11	A 12	S 13	N 14	K 15	P 16	K 17	
A 18	P 19	N 20	K 21	N 22	P 23	S 24	S 25	

The *Caricion curto-nigrae* community (NEG10) consists of a humic soil with a overlaying sandy subsoil within a infiltration system. The groundwater is acid and the site is for more than 20 years unfertilized (EGRO, 1994) (Figure 2.4).

Figure 2.4: The seed burial site Caricion (NEG10) with the different treatments per plot. The treatments are: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, S = Control without seedbags (no fertilizer).

P 1	A 2	F 3	F 4	K 5	A 6	N 7	A 8	F 9
F 10	S 11	A 12	S 13	N 14	P 15	S 16	K 17	
A 18	P 19	N 20	K 21	N 22	K 23	P 24	S 25	

The *Magnocaricion* community (NEG 11) did not receive fertilizer in the past 20 years and consists of a humic soil overlaying sandy subsoil in a nutrient-rich inundation system (EGRO, 1994) (Figure 2.5).

Figure 2.5: The different treatments per plot from the Magnocaricion (NEG11) site. The treatments are: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, S = Control without seedbags (no fertilizer).

K 1	P 2	F 3	A 4	S 5
N 6	N 7	P 8	A 9	F 10
A 11	P 12	F 13	S 14	A 15
K 16	P 17	F 18	N 19	S 20
S 21	N 22	K 23	S 24	K 25

The soil of the *Centaureo-Cynosuretum* community (GB4) consists of deep peat overlying silty clay with a calcareous infiltration from limestone hills encircling the area (Ohrmann, 1994) (Figure 2.6).

Figure 2.6: The seed burial site Centaureo-Cynosuretum (GB4) with the different treatments per plot. The treatments are: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, S = Control without seedbags (no fertilizer).

P 1	**F** 2	**P** 3	**A** 4	**K** 5
K 6	**N** 7	**S** 8	**K** 9	**N** 10
P 11	**A** 12	**F** 13	**S** 14	**F** 15
F 16	**K** 17	**S** 18	**N** 19	**A** 20
S 21	**N** 22	**P** 23	**A** 24	**S** 25

2.3. Exhumation protocol

By lifting the upper part (5-10 cm.) of the sod the seedbags are exhumed from two of the ten replicates (quadrate number 2 and 6: Figure 2.1) in the plots A, N, P, K and F in March and May 1995. The bags were put in labelled plastic bags with a site code and plot number (1-25) and stored dark and cool (4° Celsius) in a refrigerator with a relatively low air-humidity of 40-50 %.

2.4. Washing protocol

After the exhumed seedbags were washed and cleaned at the outside, the bags were opened with a sharp object (scalpel or scissors) and washed on a 1 mm. sieve on top of a 0.212 mm. sieve. The seeds were washed to get ride of the sand and soil particles and were put into coded petri-dishes (9 cm.ϕ), filled with wet filterpaper, and checked on the number of seeds (Table 2.2) and if appropriate on remains of seedcoats indicating possible early germination or decay.

2.5. Germination protocol

The petri-dishes with the seeds were stored in a cabin with a changing night and day temperature of 15-25° Celsius and alternating light of 8 hour darkness and 16 hours light (Thompson & Grime, 1979). The perti-dishes were checked for germination and humidity of the filterpaper every two or three days. The germinated seeds were counted and removed from the petri-dish if the seeds had developed at least one leaf. After 30 days the remaining seeds were tested on viability by squeezing the seed onto a hard surface. The non-viable seeds were easy to squeeze because they had already started to decompose due to rotting or fungi.

2.6. Data analysis

For the calculation of the germination percentages Microsoft-EXCEL (version 5.0) was used. The germination percentages from the different treatments were compared to the germination percentages of the blank germination test preformed in the laboratory (Bekker and Zandvoort, 1993). In the blank germination test the seeds which were collected for the seed burial project were used. The statistical analysis were carried out by using the program SX-statistics version 4.0 and SPSS/PC+ version 3.1. The germination percentages (rough germination data) were ARCSin transformed, and tested for homogeneity of variance before tested on significant differences with a One-Way-Analysis of Variance. With the program Slide Write version 5.0 the figures of this report were made.

3. Results

During the process of exhumation not all the seedbags from the different sites were found (Table 3.1). In plot 22 quadrate 6 of Calthion (NEG9), no seedbags were found due to the high groundwater level. On top of the surface of plot number 22 (N treatment) of Calthion (NEG9), a seedbag with *Lychnis flos-cuculi* seeds was found. It was not clear to which quadrate this seedbag belonged and was therefore excluded from the calculations (Appendix A). From the desiccated Calthion (NEG9D) two seedbags containing *Anthoxantum odoratum* seeds were found at the surface. The seedbags belonged to plot 6-2 and plot 18-6 (Appendix A).

Table 3.1: The missing seedbags from the different sites given per treatment with plot number and quadrate number.

Site *	Species	Treatment **	Plot no.	Quadrate no.
NEG9D	Carex acutiformis	A	11	2
	Scirpus sylvaticus	F	13	6
NEG9	Carex acutiformis	A	6	6
		K	21	6
	Filipendula ulmaria	P	16	6
		N	22	2
	Lychnis flos-cuculi	N	7	6
		A	16	2
		P	22	2
	Scirpus sylvaticus	F	9	6
		K	21	2
NEG10	Carex echinata	A	2	6
	Viola palustris	P	15	2
NEG11	Carex nigra	A	15	2
		K	23	6
		K	25	2
		K	25	6
	Lychnis flos-cuculi	P	12	6
		K	25	2
	Pedicularis palustris	A	4	2

* Sites: NEG9D = Desiccated Calthion, NEG9 = Calthion, NEG10 = Caricion curto-nigrae, NEG11 = Magnocaricion.
** Treatment: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium.

After the washing of the seeds the amount of seeds counted in the petri-dishes ranged from 30 (desiccated Calthion (NEG9D); *Filipendula ulmaria*) to 69 (Calthion (NEG9); *Scirpus sylvaticus*) (Appendix A). The amount of seeds in the seedbags before they were buried is counted by means of a machine. The calibration of the counting machine and the counting by hand after the washing of the seeds is listed in table 2.2 (Materials and Methods).
The mean germination percentages of the seeds are listed per site per treatment in table 3.2. For the complete data on germination see Appendix A.

Table 3.2: The mean germination percentages from the blank germination test (N=3) and the mean germination percentages for the different treatments (N=8) given per species per site with the viability (present/absent hard seed) of the remaining, non germinated seeds.

Site	Species	Treatment **						Viability ***
		Blank	A	N	P	K	F	
NEG9D	Lychnis flos-cuculi	97.3	93.5	84.1	93.8	87.0	93.7	+
	Scirpus sylvaticus	91.3	100	98.6	98.6	99.8	96.6	+
	Anthoxantum odoratum	24.0	15.5	21.5	17.6	16.7	15.1	+/-
	Filipendula ulmaria	68.0	42.8	51.9	44.9	44.6	33.4	+
	Carex acutiformis	34.7	46.9	37.9	45.7	44.9	46.7	+
NEG9	Lychnis flos-cuculi	97.3	82.1	64.7	76.3	84.2	81.7	+
	Scirpus sylvaticus	91.3	95.2	98.5	88.1	97.0	73.8	+
	Crepis paludosa	83.3	11.1	0.0	13.5	0.3	1.7	?
	Filipendula ulmaria	68.0	1.3	1.0	1.1	2.0	6.0	+
	Carex acutiformis	34.7	38.7	43.7	36.4	37.1	37.1	+
NEG10	Lychnis flos-cuculi	97.3	55.9	70.3	63.0	63.0	69.5	+
	Carex curta	97.7	88.5	94.5	93.4	95.4	94.1	+
	Carex echinata	92.7	99.2	95.8	95.5	99.8	99.2	+
	Viola palustris	98.0	77.7	89.9	65.0	65.9	72.7	+/-
	Potentilla palustris	0.7	7.6	22.6	4.0	4.6	7.9	+/-
NEG11	Lychnis flos-cuculi	97.3	74.9	76.1	76.8	93.1	78.1	+
	Carex nigra	30.7	73.8	70.0	62.5	67.4	69.1	+
	Pedicularis palustris	52.0	90.0	88.2	87.7	75.6	81.6	+/-
	Senecio aquatica	88.0	84.9	79.4	83.1	79.3	87.5	+
	Ranunculus flammula	37.3	43.2	52.5	47.4	47.3	38.3	+
GB4	Lychnis flos-cuculi	81.3	60.3	38.9	46.6	26.1	52.6	+
	Carex hostiana	42.0	81.1	89.8	94.6	76.2	85.2	+
	Carex flacca	46.0	60.2	72.6	73.2	77.3	61.7	+
	Potentilla erecta	48.7	40.0	43.6	34.1	32.3	38.7	+/-
	Filipendula ulmaria	68.0	40.1	57.3	45.0	36.3	42.0	+

* Sites: NEG9D = Desiccated Calthion, NEG9 = Calthion, NEG10 = Caricion curto-nigrae, NEG11 = Magnocaricion, GB4 = Centaureo-Cynosuretum.
** Treatment: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, S = Control without seedbags (no fertilizer).
*** Viability: + = all viable seeds, +/- = viable and non viable seeds, ? = unknown.

After 30 days not all seeds had germinated. Most of the remaining seeds were still viable, except seeds of *Anthoxantum odoratum*, *Viola palustris*, *Potentilla palustris*, *Potentilla erecta* and *Pedicularis palustris* due to fungi or rot (Table 3.2).

The germination percentages of the A-treatment (control with seedbags, no fertilizer) shows some differences when compared to the blank germination test. The seeds of the species *Filipendula ulmaria* and *Crepis paludosa* (NEG9) were less viable after one year of burying. Where as the seeds of the species *Potentilla palustris* (NEG10), *Carex nigra*, *Pedicularis palustris* (NEG11), *Carex hostiana* and *Carex flacca* (GB4) had much higher germination percentages compared to the blank germination test (Bekker & Zandvoort, 1993). Almost all species show a mean germination percentage of about 50 % and higher except the species *Filipendula ulmaria* and *Crepis paludosa* (NEG9) and *Anthoxantum odoratum* from the NEG9D site with a percentage of less than 22 % (Figure 3.1a - 3.1e). In all sites seed of *Lychnis flos-cuculi* were buried. The mean germination percentages of the *Lychnis flos-cuculi* seeds were in all sites lower compared to the blank germination test.

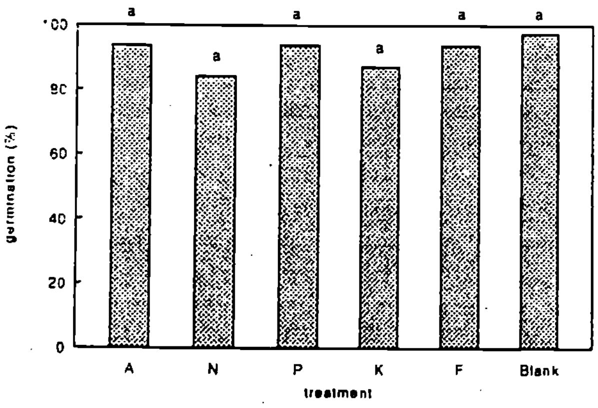
There are no significant differences in germination percentage found between the treatments within the species of each site (One-Way AOV, rejection level 0.050; Figure 3.1a-3.1e; Appendix B). Between the germination percentages of the treatments and the blank germination test significant differences sites are found (One-Way AOV, rejection level 0.050; Figure 3.1a-3.1e; Appendix B).

The germination percentage of all treatments of the species *Anthoxantum odoratum*, *Filipendula ulmaria* and *Scirpus sylvaticus* from NEG9D are significantly lower compared to blank germination test, with exception of the N-treatment from *Anthoxantum odoratum* and *Filipendula ulmaria* (One Way AOV $p<0.05$; Figure 3.1a). In the NEG9 site *Filipendula ulmaria* and *Crepis paludosa* show significant lower germination percentages then the blank germination test (One-Way AOV, $p<0.0001$; Figure 3.1b).

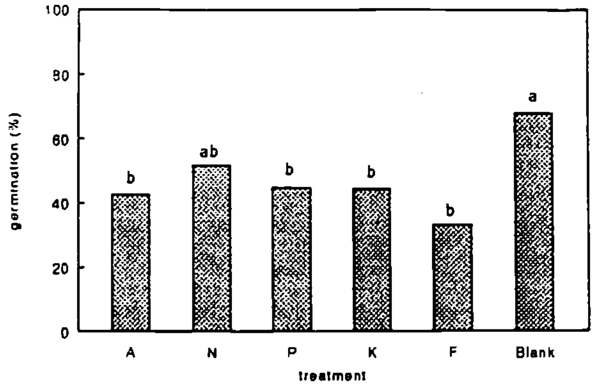
Figure 3.1: The mean germination percentages of the species of the sites (a) NEG9D (desiccated Calthion), (b) NEG9-site (Calthion), (c) NEG10-site (Caricion), (d) NEG11-site (Magnocaricion) and (e) GB4-site (Centaureo-Cynosuretum) given per species, per treatment. Any two columns with the same letter are not significantly different.

3.1a) The mean germination percentages of the site NEG9D per species, per treatment.

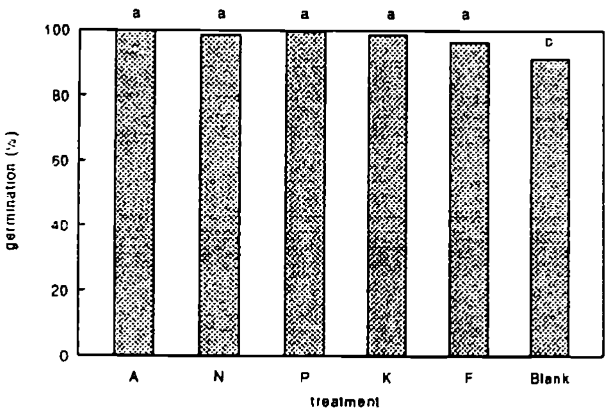
Lychnis flos-cuculi



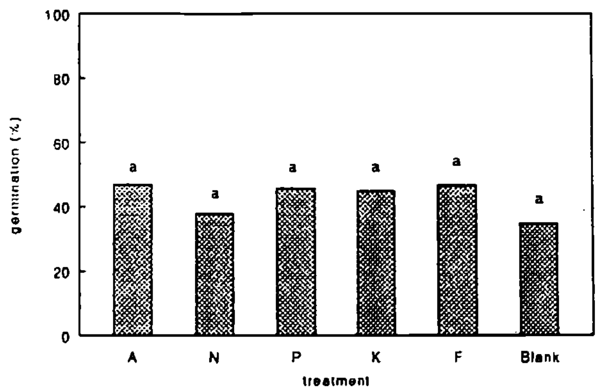
Filipendula ulmaria



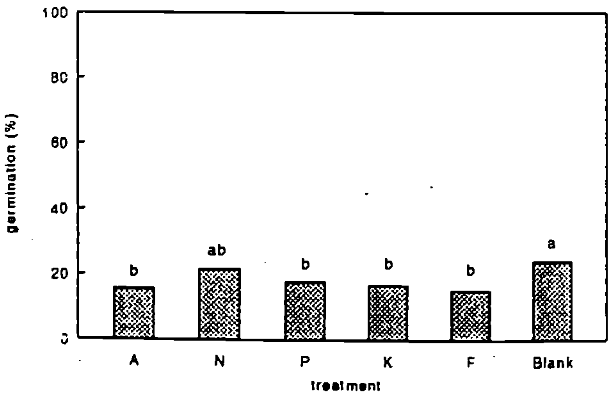
Scirpus sylvaticus



Carex acutiformis



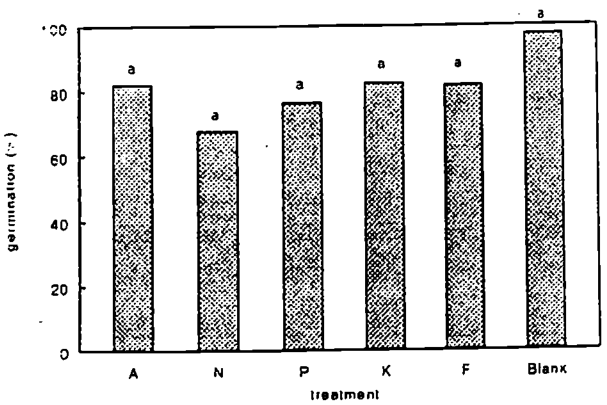
Anthoxantum odoratum



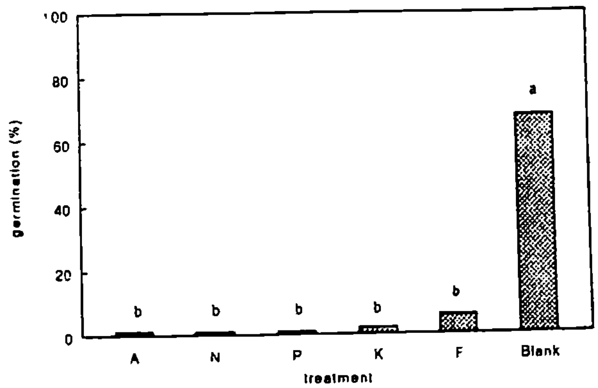
The treatments: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, Blank = blank germination test (laboratory).

3.1b) The mean germination percentages of the site NEG9 per species, per treatment.

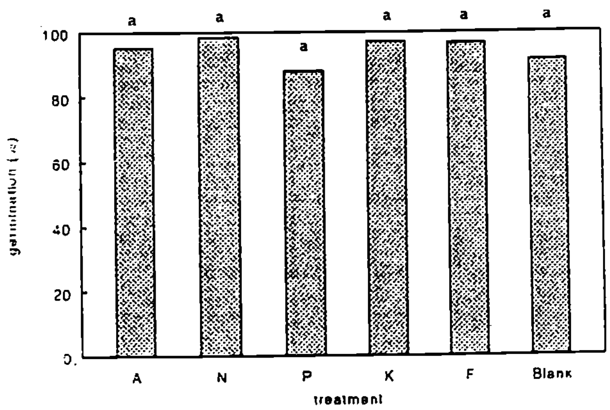
Lychnis flos-cuculi



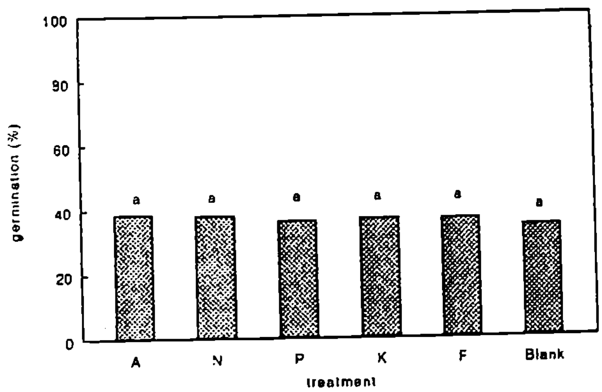
Filipendula ulmaria



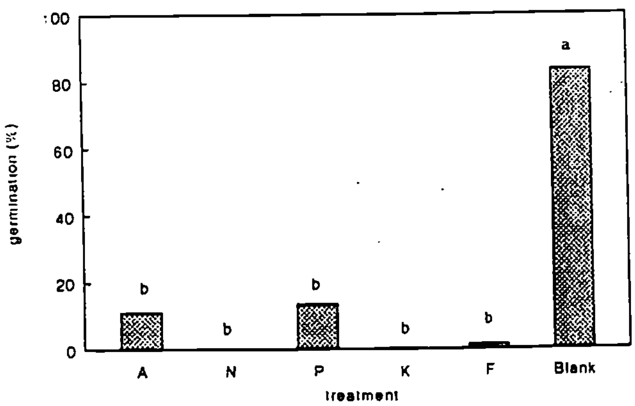
Scirpus sylvaticus



Carex acutiformis



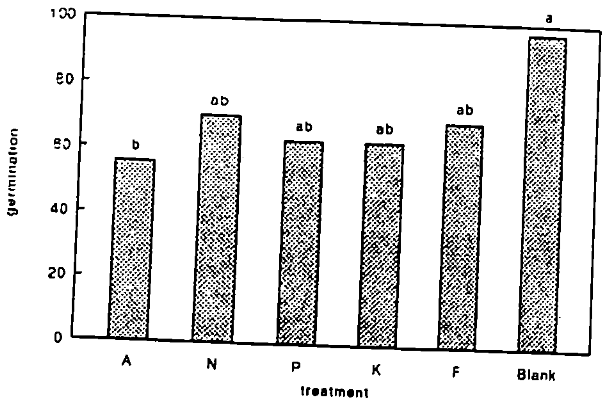
Crepis paludosa



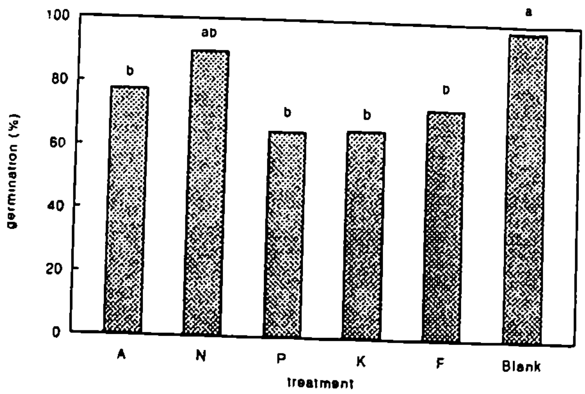
The treatments: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, Blank = blank germination test (laboratory).

3.1c) The mean germination percentages of the site NEG10 per species, per treatment.

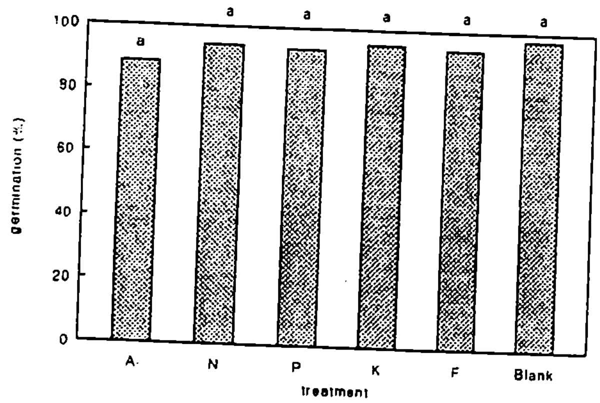
Lychnis flos-cuculi



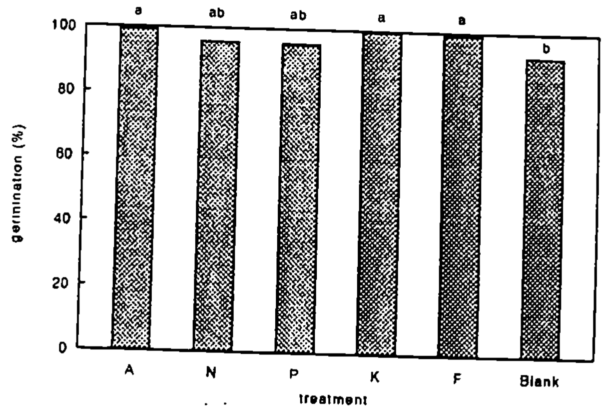
Viola palustris



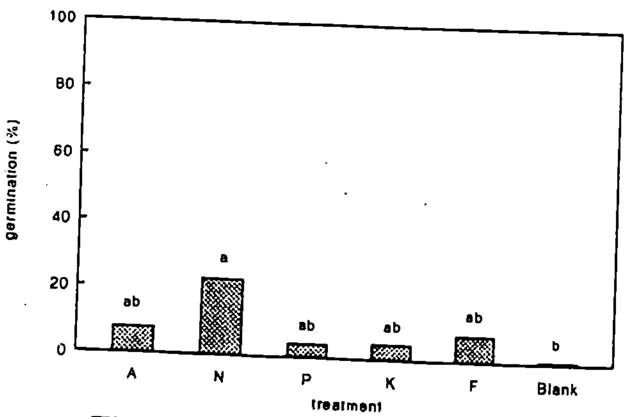
Carex curta



Carex echinata



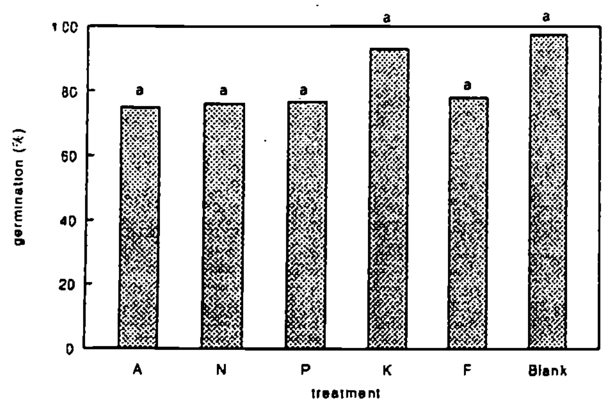
Potentilla palustre



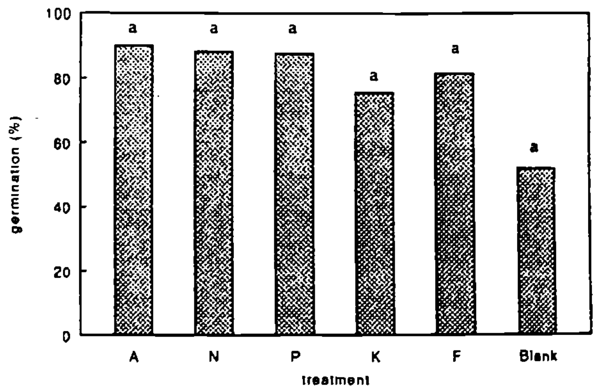
The treatments: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, Blank = blank germination test (laboratory).

3.1d) The mean germination percentages of the site NEG11 per species, per treatment.

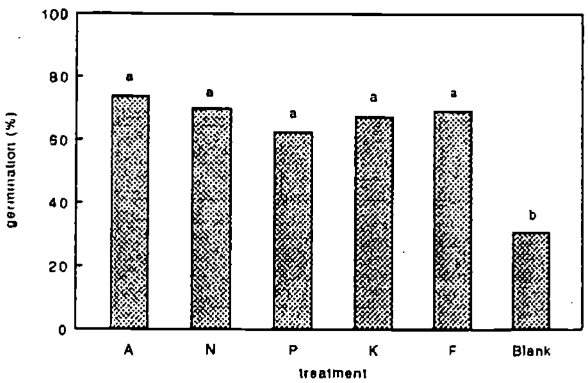
Lychnis flos-cuculi



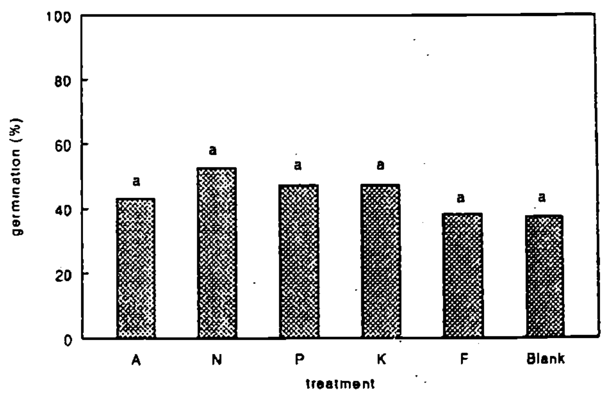
Pedicularis palustre



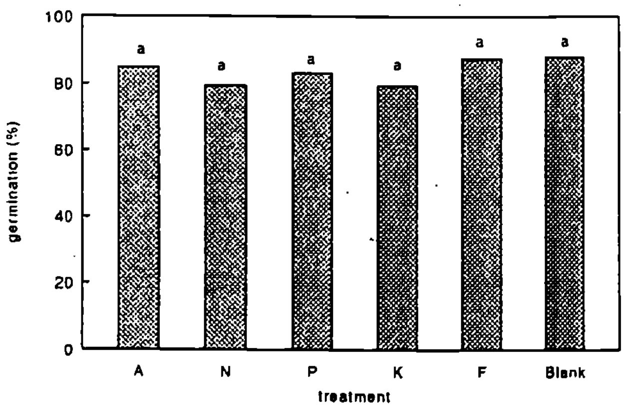
Carex nigra



Ranunculus flammula



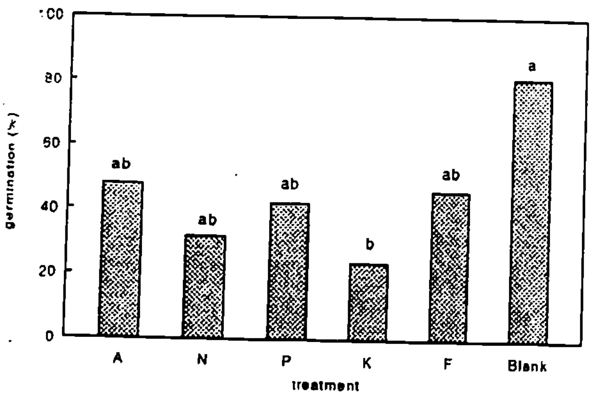
Senecio aquatica



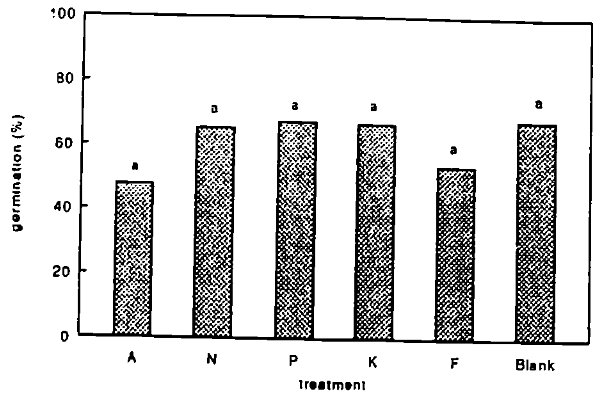
The treatments: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, Blank = blank germination test (laboratory).

3.1e) The mean germination percentages of the site GB4 per species, per treatment.

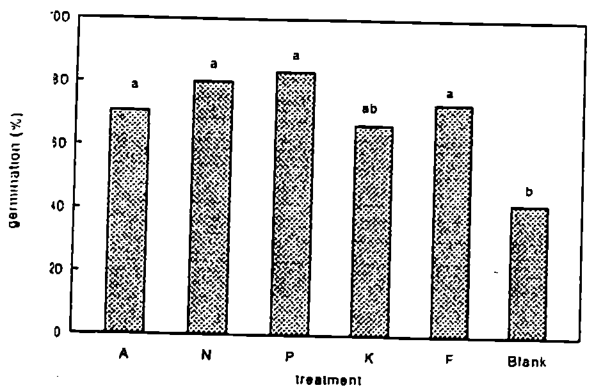
Lychnis flos-cuculi



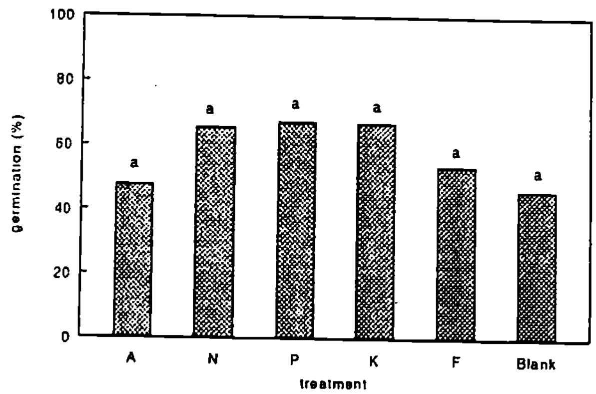
Filipendula ulmaria



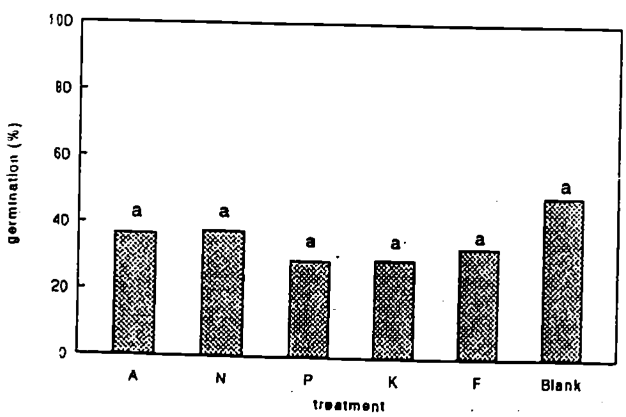
Carex hostiana



Carex flacca



Potentilla erecta



The treatments: A = Control with seed bags (no fertilizer), N = Nitrogen, P = Phosphorus, K = Potassium, F = Nitrogen, Phosphorus and Potassium, Blank = blank germination test (laboratory).

In the NEG10 site the species *Viola palustris* and *Carex echinata* (A-, K- and F-treatment) show a significant lower percentage, whereas *Potentilla palustris* (N-treatment) show significant higher germination percentage compared to the blank germination test (Figure 3.1c). The germination percentages of *Carex nigra* (NEG11) shows for all treatments significant higher germination percentages when compared to the blank germination test (One-Way AOV, $p<0.005$; Figure 3.1d). In the GB4 site the species *Lychnis flos-cuculi* (K-treatment) shows a significant lower germination percentage compared to the blank germination test, whereas *Carex hostiana* (N-, P- and F-treatment) show a significant different higher germination percentages (One-Way AOV, $p<0.05$; Figure 3.1e).

There are no significant differences between the fertilizer treatments within the sites (One-Way AOV, rejection level 0.050; Appendix B). Between species within treatments and also between species within sites there are significant differences in germination percentages found. The Tukey's Pairwise Comparison of Means-test shows various homogeneous groups in which the means are not significantly different from one another.

Between sites within the treatments A, N, K and F there are significant differences found (One-Way AOV, $p<0.050$; Appendix B).

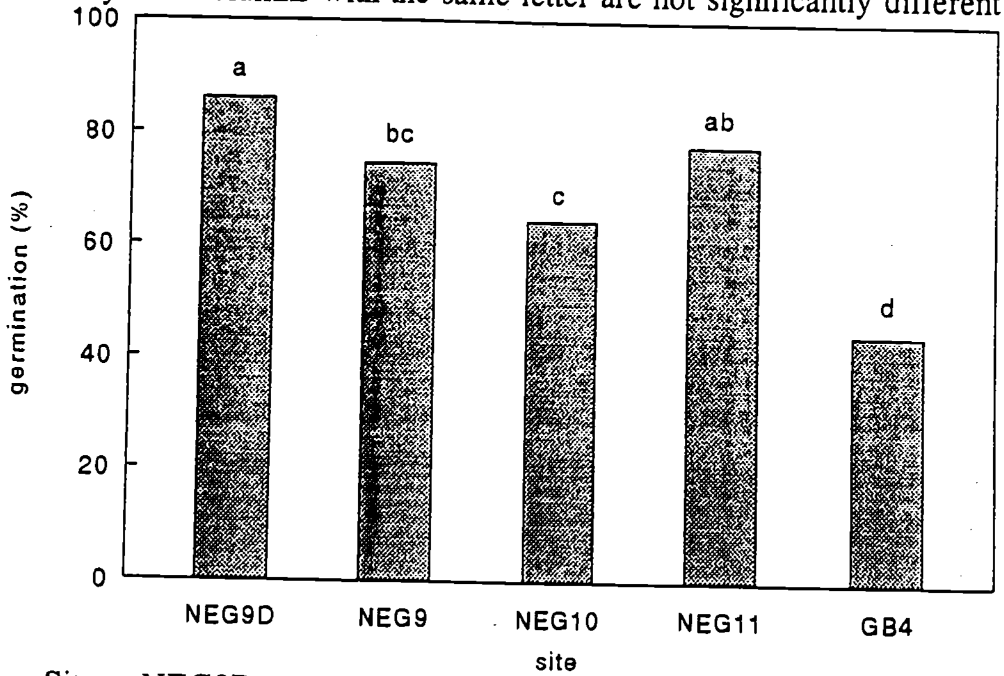
For the species *Lychnis flos-cuculi*, *Filipendula ulmaria*, *Scirpus sylvaticus* and *Carex acutiformis* site differences are determined (Appendix B). There are significant differences in germination of *Lychnis flos-cuculi* between the sites (One-Way AOV, $p<0.0001$; Figure 3.2). The Tukey's Pairwise Comparison of Means-test shows four groups in which the means are significantly different from one another. The mean germination of *Lychnis flos-cuculi* from NEG9D shows the highest percentages (Figure 3.2). The GB4 site shows the lowest mean germination (Figure 3.2).

The germination of *Filipendula ulmaria* significantly differs between the sites NEG9D, NEG9 and GB4 (One-Way AOV, $p<0.0001$; Figure 3.3). The germination percentages of the sites NEG9D and GB4 are significantly higher than the mean percentage of the NEG9 site.

The mean germination percentage of *Scirpus sylvaticus* and *Carex acutiformis* from the sites NEG9D and NEG9 are not significantly different from each other (One-Way AOV, $p=0.0713$ and $p=0.0135$; Figure 3.4 and Figure 3.5).

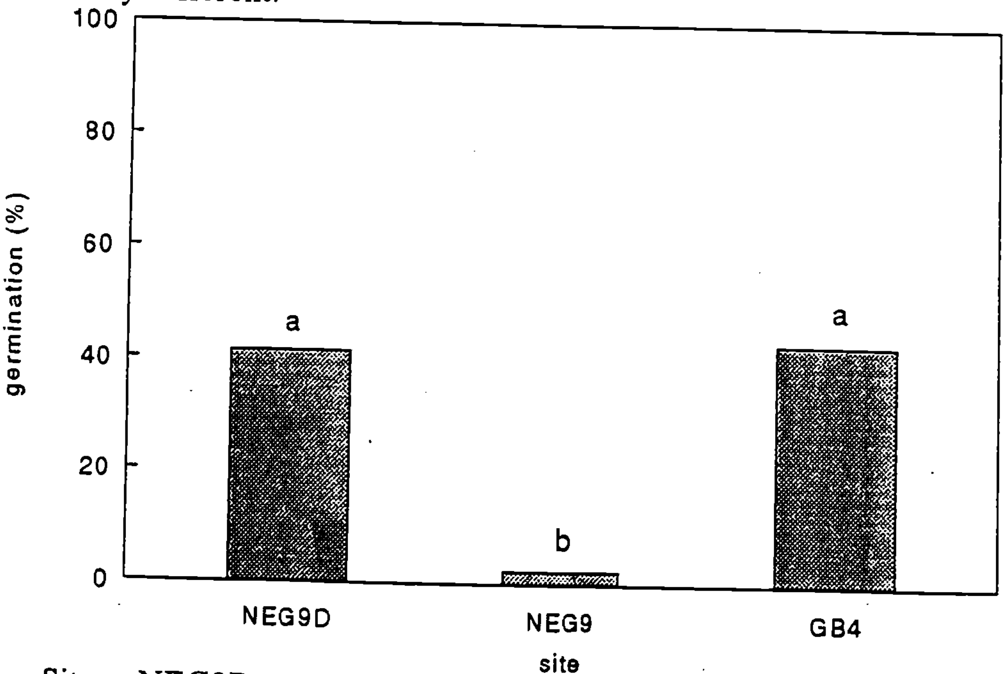
There are no interaction effects between the treatments and the sites (Two-Way AOV, rejection level $p=0.05$).

Figure 3.2: The mean germination percentages per site from *Lychnis flos-cuculi*. Any two columns with the same letter are not significantly different.



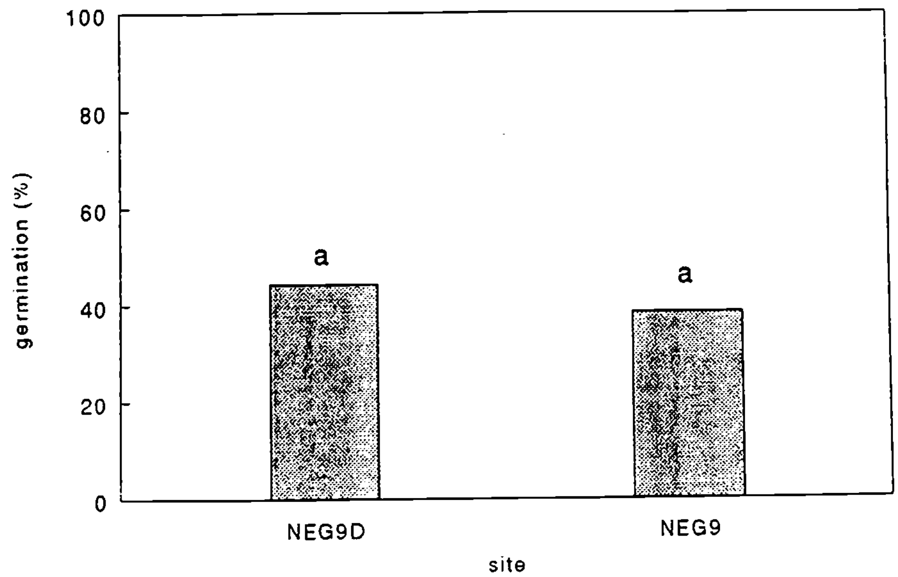
Sites: NEG9D = Desiccated Calthion, NEG9 = Calthion, NEG10 = Caricion curto-nigrae, NEG11 = Magnocaricion, GB4 = Centaureo-Cynosuretum.

Figure 3.3: The mean germination percentages per site (NEG9D, NEG9 and GB4) from *Filipendula ulmaria*. Any two columns with the same letter are not significantly different.



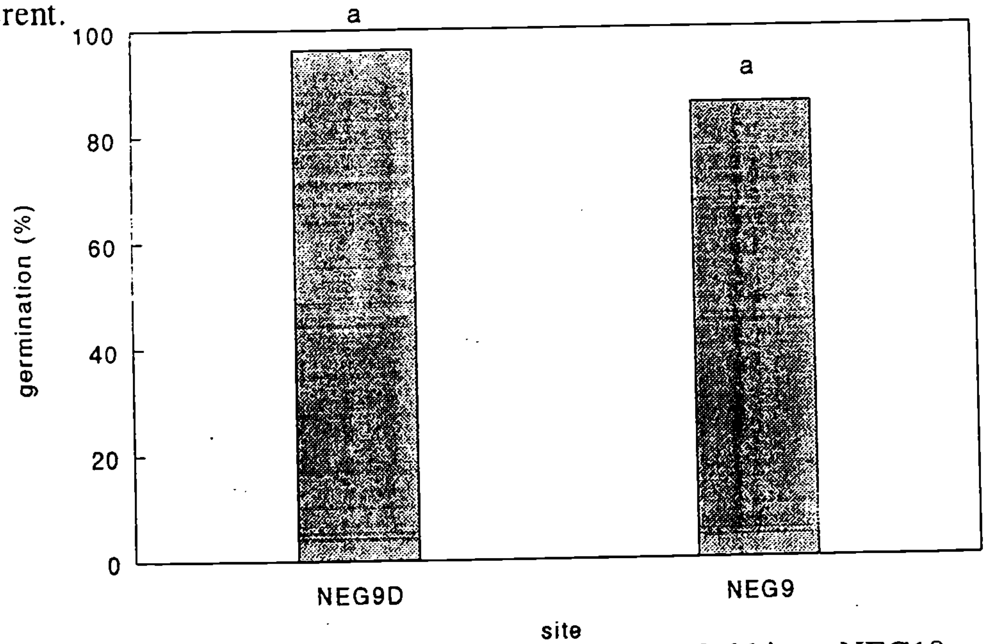
Sites: NEG9D = Desiccated Calthion, NEG9 = Calthion, NEG10 = Caricion curto-nigrae, NEG11 = Magnocaricion, GB4 = Centaureo-Cynosuretum.

Figure 3.4: The mean germination percentages from *Scirpus sylvaticus* on the sites NEG9D and NEG9. Any two columns with the same letter are not significantly different.



Sites: NEG9D = Desiccated Calthion, NEG9 = Calthion, NEG10 = Caricion curto-nigrae, NEG11 = Magnocaricion, GB4 = Centaureo-Cynosuretum.

Figure 3.9: The mean germination percentages from *Carex acutiformis* on the sites NEG9D and NEG9. Any two columns with the same letter are not significantly different.



Sites: NEG9D = Desiccated Calthion, NEG9 = Calthion, NEG10 = Caricion curto-nigrae, NEG11 = Magnocaricion, GB4 = Centaureo-Cynosuretum.

4. Discussion and Conclusions

The objective of the seed burial project (EGRO: Task 2) is to establish the impact of high nitrogen, phosphorus and potassium availability on the longevity of seeds of grassland wild flower species. The expectation of this first year of exhuming and testing of the seeds is that there are no significant differences in viability of the seeds between the different fertilizer treatments within the species of the sites. The results from this report follow this expectation to some extent, but there are some significant differences between the different fertilizer treatments.
The N-treatment shows in the sites NEG9D, NEG9, NEG10 and NEG11 the most significantly differences in the germination percentages within some of the species. In site GB4 the K-treatment shows the most significant differences within some of the species. The F-treatment shows no significant differences within the species of all sites.

It is important to consider the fact that seed viability is not only a function of seed storage. A variety of factors to which the parent plant is exposed during seed formation and ripening can also profoundly affect subsequent viability of the seeds, after dispersion or harvest. Such factors include water supply, temperature, mineral nutrition and light. However, these environmental factors are secondary in importance, compared to the genetic control of seed viability (Mayer & Poljakoff-Mayer, 1975).

Germination

The pre-check on the total number of seeds and seedcoats, from germinated seeds, before washing is almost impossible due to sand and soil particles. Therefore, the seeds are counted in the petri-dishes after washing. Table 2.2 shows some difference in amount of seeds counted by machine (before burial) compared to the counting by hand (after burial, after washing). Counting by hand after washing always gives lower amounts. An explanation for this can be removal of the seeds by predation or rotting of the seeds when buried in the soil, or too early germination of the seeds in the soil. This germination in the darkness can be caused by Nitrate (N). Nitrate can break dormancy in many species, either on its own or in combination with temperature (Pons, 1989). The washing of the seeds is a rough method especially for fragile seeds as *Filipendula ulmaria* and *Crepis paludosa* because the seeds can be damaged and this can have an effect on the germination data. After the washing there are still a lot of remains in the petri-dishes and due to washing some of the seeds loose their seedcoats, this makes the counting difficult and not very accurate. Beside that, the amount of seeds in the seedbags was not always fifty but varied from 30 (Calthion Desiccated, *Filipendula ulmaria*) to 69 seeds (Calthion, *Scirpus sylvaticus*). The conclusion from this is that the counting of the seeds in the petri-dishes can also be of influence on the germination data.

Froud-Williams, Chancellor and Drennan (1984) showed that burial of small-seeded species both delayed and reduced seedling emergence, and, in contrast, germination of the larger-seeded species was increased by burial.
Most of the germination percentages of the seeds from the burial sites are lying, after one year of burying, in the same range as the germination percentages of the blank germination test (Bekker and Zandvoort, 1993). But there doesn't seem to be a correlation with the sizes of the seeds.

There are some significant differences in germination of the seeds between the different fertilizer treatments within species and within sites. As can be expected, there are significant differences between the species within the treatments and within the sites. The statistical analysis also shows an overall site effect: between sites which share species there are significant differences in germination percentage. For example the seeds of *Filipendula ulmaria* from the Calthion site show a very low germination percentage, whereas the germination percentages of *F. ulmaria* from the desiccated Calthion is almost 100 (Results table 3.2). This effect cannot be caused by differences between the buried seeds, because they were collected from the same site at the same time and the seedbags from both the sites contained the same Calthion soil. The only distinction is that the Calthion site has been flooded for a long time during the spring. It has been suggested that seeds may remain viable longer if the soil is waterlogged (Howe and Chancellor, 1983). Apparently, the differences between the germination percentages of *F. ulmaria* are due to a site difference. The analysis show that the sites are also significantly different within the different fertilizer treatments: the germination of the seeds on the Calthion site (NEG9) is in all treatments lower than the other sites.

After 30 days of incubation most of the remaining seeds were still viable, but why did they not germinate? Maybe because of the fact that the incubation period of 30 days is short compared to the period Bekker & Zandvoort (1993) took. For example in the sites desiccated Calthion and Calthion, *Carex acutiformis* has a low germination percentage compared to the blank germination test. The seeds of *C. acutiformis* were still viable after 30 days of incubation, whereas Bekker & Zandvoort (1993) had an incubation period of 73 days. Nevertheless, the seeds of most of the species in the blank germination test germinated within the first 30 days (Bekker & Zandvoort, 1993). Another reason could be that the still viable seeds are in an enforced dormancy which prevents germination (Fenner, 1985). The buried seeds have been stratified naturally over winter but maybe because of methods used or unfavourable circumstances, for example insufficient moisture, light or unsuitable temperature (Fenner, 1985).
To test this, the seeds could be stratified (again) in the dark for a few weeks with a temperature of 4° Celsius. After the stratifying they can be tested on viability by means of germination.

Conclusion

After one year of burial and three years of fertilizing there are some significant differences in viability of the seeds between the A, N, P and K fertilizer treatments within the species over all sites. The significant differences found between the sites which share species is due to site differences and not to the fertilizer treatments.

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Appendix

Appendix A: Complete germination data from the sites: Calthion desiccated (NEG9D), Calthion (NEG9), Caricion curto-nigrae (NEG10), Magnocaricion (NEG11) and Centaureo-Cynosuretum (GB4).

Species:
Anthox.o. - Anthoxantum odoratum
Carex curt. - Carex curta
Carex ech. - Carex echinata
Carex flac. - Carex flacca
Carex hos. - Carex hostiana
Carex nig. - Carex nigra
Crepi.pal. - Crepis paludosa
Filip.ulm. - Filipendula ulmaria
Lych.flos - Lychnis flos-cuculi
Pedicu.pal. - Pedicularis palustris
Pot.erec. - Potentilla erecta
Pot.pal. - Potentilla palustris
Ranuc.fla. - Ranunculus Flammula
Scirp.sylv. - Scirpus sylvaticus
Seneci.aq.- Senecio aquatica
Viola pal. - Viola palustris

Treatments:
N - Nitrate treatment
P - Phosphorus treatment
K - Potassium treatment
F - Full treatment with NPK
S - no treatment (control)

Before - Total number of seeds recovered after burial
After - Total number of seeds germinated

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Calth.dry	1	2	A	Lych.flos	52	52	100.00%
Calth.dry	1	6	A	Lych.flos	47	34	72.34%
Calth.dry	1	2	A	Scirp.sylv.	44	44	100.00%
Calth.dry	1	6	A	Scirp.sylv.	49	49	100.00%
Calth.dry	1	2	A	Anthox.o.	56	6	10.71%
Calth.dry	1	6	A	Anthox.o.	48	7	14.58%
Calth.dry	1	2	A	Filip.ulm.	44	20	45.45%
Calth.dry	1	6	A	Filip.ulm.	42	22	52.38%
Calth.dry	1	2	A	Carex acu	48	21	43.75%
Calth.dry	1	6	A	Carex acu	45	28	62.22%
Calth.dry	2	2	F	Lych.flos	47	47	100.00%
Calth.dry	2	6	F	Lych.flos	44	44	100.00%
Calth.dry	2	2	F	Scirp.sylv.	46	46	100.00%
Calth.dry	2	6	F	Scirp.sylv.	49	45	91.84%
Calth.dry	2	2	F	Anthox.o.	49	4	8.16%
Calth.dry	2	6	F	Anthox.o.	49	11	22.45%
Calth.dry	2	2	F	Filip.ulm.	43	9	20.93%
Calth.dry	2	6	F	Filip.ulm.	39	15	38.46%
Calth.dry	2	2	F	Carex acu	46	17	36.96%
Calth.dry	2	6	F	Carex acu	42	18	42.86%
Calth.dry	3	2	N	Lych.flos	47	41	87.23%
Calth.dry	3	6	N	Lych.flos	45	45	100.00%
Calth.dry	3	2	N	Scirp.sylv.	46	46	100.00%
Calth.dry	3	6	N	Scirp.sylv.	49	49	100.00%
Calth.dry	3	2	N	Anthox.o.	46	7	15.22%
Calth.dry	3	6	N	Anthox.o.	53	6	11.32%
Calth.dry	3	2	N	Filip.ulm.	47	35	74.47%
Calth.dry	3	6	N	Filip.ulm.	48	48	100.00%
Calth.dry	3	2	N	Carex acu	45	14	31.11%
Calth.dry	3	6	N	Carex acu	43	15	34.88%
Calth.dry	4	2	A	Lych.flos	50	47	94.00%
Calth.dry	4	6	A	Lych.flos	45	45	100.00%
Calth.dry	4	2	A	Scirp.sylv.	49	49	100.00%
Calth.dry	4	6	A	Scirp.sylv.	44	44	100.00%
Calth.dry	4	2	A	Anthox.o.	47	4	8.51%
Calth.dry	4	6	A	Anthox.o.	49	5	10.20%
Calth.dry	4	2	A	Filip.ulm.	42	24	57.14%
Calth.dry	4	6	A	Filip.ulm.	36	12	33.33%
Calth.dry	4	2	A	Carex acu	39	18	46.15%
Calth.dry	4	6	A	Carex acu	48	22	45.83%
Calth.dry	5	2	K	Lych.flos	50	50	100.00%
Calth.dry	5	6	K	Lych.flos	50	40	80.00%
Calth.dry	5	2	K	Scirp.sylv.	51	51	100.00%
Calth.dry	5	6	K	Scirp.sylv.	47	47	100.00%
Calth.dry	5	2	K	Anthox.o.	53	7	13.21%
Calth.dry	5	6	K	Anthox.o.	52	5	9.62%
Calth.dry	5	2	K	Filip.ulm.	44	10	22.73%
Calth.dry	5	6	K	Filip.ulm.	43	20	46.51%
Calth.dry	5	2	K	Carex acu	48	24	50.00%
Calth.dry	5	6	K	Carex acu	51	20	39.22%
Calth.dry	6	2	N	Lych.flos	49	46	93.88%
Calth.dry	6	6	N	Lych.flos	49	42	85.71%
Calth.dry	6	2	N	Scirp.sylv.	45	45	100.00%
Calth.dry	6	6	N	Scirp.sylv.	42	42	100.00%
Calth.dry	6	2	N	Anthox.o.	60	3	5.00%
Calth.dry	6	6	N	Anthox.o.	45	6	13.33%
Calth.dry	6	2	N	Filip.ulm.	38	5	13.16%
Calth.dry	6	6	N	Filip.ulm.	37	17	45.95%
Calth.dry	6	2	N	Carex acu	44	15	34.09%
Calth.dry	6	6	N	Carex acu	46	21	45.65%
Calth.dry	7	2	P	Lych.flos	48	48	100.00%
Calth.dry	7	6	P	Lych.flos	51	49	96.08%
Calth.dry	7	2	P	Scirp.sylv.	48	48	100.00%
Calth.dry	7	6	P	Scirp.sylv.	49	49	100.00%
Calth.dry	7	2	P	Anthox.o.	45	8	17.78%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Calth.dry	7	6	P	Anthox.o.	43	4	9.30%
Calth.dry	7	2	P	Filip.ulm.	39	2	5.13%
Calth.dry	7	6	P	Filip.ulm.	34	21	61.76%
Calth.dry	7	2	P	Carex acu	41	24	58.54%
Calth.dry	7	6	P	Carex acu	46	13	28.26%
Calth.dry	8	2	N	Lych.flos	52	45	86.54%
Calth.dry	8	6	N	Lych.flos	46	16	34.78%
Calth.dry	8	2	N	Scirp.sylv.	45	40	88.89%
Calth.dry	8	6	N	Scirp.sylv.	46	46	100.00%
Calth.dry	8	2	N	Anthox.o.	53	5	9.43%
Calth.dry	8	6	N	Anthox.o.	50	4	8.00%
Calth.dry	8	2	N	Filip.ulm.	44	2	4.55%
Calth.dry	8	6	N	Filip.ulm.	42	15	35.71%
Calth.dry	8	2	N	Carex acu	45	15	33.33%
Calth.dry	8	6	N	Carex acu	45	17	37.78%
Calth.dry	9	2	P	Lych.flos	49	30	61.22%
Calth.dry	9	6	P	Lych.flos	50	50	100.00%
Calth.dry	9	2	P	Scirp.sylv.	45	45	100.00%
Calth.dry	9	6	P	Scirp.sylv.	50	49	98.00%
Calth.dry	9	2	P	Anthox.o.	49	15	30.61%
Calth.dry	9	6	P	Anthox.o.	46	19	41.30%
Calth.dry	9	2	P	Filip.ulm.	44	27	61.36%
Calth.dry	9	6	P	Filip.ulm.	33	20	60.61%
Calth.dry	9	2	P	Carex acu	50	21	42.00%
Calth.dry	9	6	P	Carex acu	51	28	54.90%
Calth.dry	10	2	F	Lych.flos	48	48	100.00%
Calth.dry	10	6	F	Lych.flos	50	50	100.00%
Calth.dry	10	2	F	Scirp.sylv.	49	49	100.00%
Calth.dry	10	6	F	Scirp.sylv.	45	45	100.00%
Calth.dry	10	2	F	Anthox.o.	45	7	15.56%
Calth.dry	10	6	F	Anthox.o.	53	7	13.21%
Calth.dry	10	2	F	Filip.ulm.	40	11	27.50%
Calth.dry	10	6	F	Filip.ulm.	39	14	35.90%
Calth.dry	10	2	F	Carex acu	47	25	53.19%
Calth.dry	10	6	F	Carex acu	44	19	43.18%
Calth.dry	11	2	A	Lych.flos	49	49	100.00%
Calth.dry	11	6	A	Lych.flos	45	43	95.56%
Calth.dry	11	2	A	Scirp.sylv.	45	45	100.00%
Calth.dry	11	6	A	Scirp.sylv.	44	44	100.00%
Calth.dry	11	2	A	Anthox.o.	46	7	15.22%
Calth.dry	11	6	A	Anthox.o.	55	11	20.00%
Calth.dry	11	2	A	Filip.ulm.	46	13	28.26%
Calth.dry	11	6	A	Filip.ulm.	44	27	61.36%
Calth.dry	11	2	A	Carex acu			
Calth.dry	11	6	A	Carex acu	45	24	53.33%
Calth.dry	12	2	P	Lych.flos	40	39	97.50%
Calth.dry	12	6	P	Lych.flos	48	46	95.83%
Calth.dry	12	2	P	Scirp.sylv.	52	52	100.00%
Calth.dry	12	6	P	Scirp.sylv.	47	47	100.00%
Calth.dry	12	2	P	Anthox.o.	49	9	18.37%
Calth.dry	12	6	P	Anthox.o.	56	4	7.14%
Calth.dry	12	2	P	Filip.ulm.	48	27	56.25%
Calth.dry	12	6	P	Filip.ulm.	44	28	63.64%
Calth.dry	12	2	P	Carex acu	46	24	52.17%
Calth.dry	12	6	P	Carex acu	47	18	38.30%
Calth.dry	13	2	F	Lych.flos	51	40	78.43%
Calth.dry	13	6	F	Lych.flos	50	50	100.00%
Calth.dry	13	2	F	Scirp.sylv.	47	47	100.00%
Calth.dry	13	6	F	Scirp.sylv.			
Calth.dry	13	2	F	Anthox.o.	49	9	18.37%
Calth.dry	13	6	F	Anthox.o.	52	8	15.38%
Calth.dry	13	2	F	Filip.ulm.	47	19	40.43%
Calth.dry	13	6	F	Filip.ulm.	42	18	42.86%
Calth.dry	13	2	F	Carex acu	44	17	38.64%
Calth.dry	13	6	F	Carex acu	48	26	54.17%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Calth.dry	14	2	P	Lych.flos	49	49	100.00%
Calth.dry	14	6	P	Lych.flos	44	44	100.00%
Calth.dry	14	2	P	Scirp.sylv.	43	43	100.00%
Calth.dry	14	6	P	Scirp.sylv.	45	45	100.00%
Calth.dry	14	2	P	Anthox.o.	50	5	10.00%
Calth.dry	14	6	P	Anthox.o.	49	3	6.12%
Calth.dry	14	2	P	Filip.ulm.	43	13	30.23%
Calth.dry	14	6	P	Filip.ulm.	44	9	20.45%
Calth.dry	14	2	P	Carex acu	43	22	51.16%
Calth.dry	14	6	P	Carex acu	45	18	40.00%
Calth.dry	15	2	K	Lych.flos	46	34	73.91%
Calth.dry	15	6	K	Lych.flos	50	46	92.00%
Calth.dry	15	2	K	Scirp.sylv.	47	47	100.00%
Calth.dry	15	6	K	Scirp.sylv.	48	48	100.00%
Calth.dry	15	2	K	Anthox.o.	51	9	17.65%
Calth.dry	15	6	K	Anthox.o.	36	3	8.33%
Calth.dry	15	2	K	Filip.ulm.	46	22	47.83%
Calth.dry	15	6	K	Filip.ulm.	41	10	24.39%
Calth.dry	15	2	K	Carex acu	47	13	27.66%
Calth.dry	15	6	K	Carex acu	50	13	26.00%
Calth.dry	16	2	F	Lych.flos	49	43	87.76%
Calth.dry	16	6	F	Lych.flos	48	40	83.33%
Calth.dry	16	2	F	Scirp.sylv.	50	42	84.00%
Calth.dry	16	6	F	Scirp.sylv.	48	48	100.00%
Calth.dry	16	2	F	Anthox.o.	45	5	11.11%
Calth.dry	16	6	F	Anthox.o.	48	8	16.67%
Calth.dry	16	2	F	Filip.ulm.	44	10	22.73%
Calth.dry	16	6	F	Filip.ulm.	42	16	38.10%
Calth.dry	16	2	F	Carex acu	50	33	66.00%
Calth.dry	16	6	F	Carex acu	49	19	38.78%
Calth.dry	17	2	A	Lych.flos	54	49	90.74%
Calth.dry	17	6	A	Lych.flos	45	43	95.56%
Calth.dry	17	2	A	Scirp.sylv.	52	52	100.00%
Calth.dry	17	6	A	Scirp.sylv.	46	46	100.00%
Calth.dry	17	2	A	Anthox.o.	52	11	21.15%
Calth.dry	17	6	A	Anthox.o.	47	11	23.40%
Calth.dry	17	2	A	Filip.ulm.	39	13	33.33%
Calth.dry	17	6	A	Filip.ulm.	42	13	30.95%
Calth.dry	17	2	A	Carex acu	50	13	26.00%
Calth.dry	17	6	A	Carex acu	41	21	51.22%
Calth.dry	18	2	K	Lych.flos	45	44	97.78%
Calth.dry	18	6	K	Lych.flos	49	44	89.80%
Calth.dry	18	2	K	Scirp.sylv.	47	47	100.00%
Calth.dry	18	6	K	Scirp.sylv.	47	42	89.36%
Calth.dry	18	2	K	Anthox.o.	46	7	15.22%
Calth.dry	18	6	K	Anthox.o.	48	4	8.33%
Calth.dry	18	2	K	Filip.ulm.	47	32	68.09%
Calth.dry	18	6	K	Filip.ulm.	47	20	42.55%
Calth.dry	18	2	K	Carex acu	44	28	63.64%
Calth.dry	18	6	K	Carex acu	45	29	64.44%
Calth.dry	19	2	K	Lych.flos	42	28	66.67%
Calth.dry	19	6	K	Lych.flos	51	49	96.08%
Calth.dry	19	2	K	Scirp.sylv.	48	48	100.00%
Calth.dry	19	6	K	Scirp.sylv.	48	48	100.00%
Calth.dry	19	2	K	Anthox.o.	54	16	29.63%
Calth.dry	19	6	K	Anthox.o.	44	14	31.82%
Calth.dry	19	2	K	Filip.ulm.	38	23	60.53%
Calth.dry	19	6	K	Filip.ulm.	32	14	43.75%
Calth.dry	19	2	K	Carex acu	48	25	52.08%
Calth.dry	19	6	K	Carex acu	47	17	36.17%
Calth.dry	20	2	N	Lych.flos	52	44	84.62%
Calth.dry	20	6	N	Lych.flos	48	48	100.00%
Calth.dry	20	2	N	Scirp.sylv.	48	48	100.00%
Calth.dry	20	6	N	Scirp.sylv.	51	51	100.00%
Calth.dry	20	2	N	Anthox.o.	43	4	9.30%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Calth.dry	20	6	N	Anthox.o.	47	47	100.00%
Calth.dry	20	2	N	Filip.ulm.	44	27	61.36%
Calth.dry	20	6	N	Filip.ulm.	30	24	80.00%
Calth.dry	20	2	N	Carex acu	40	18	45.00%
Calth.dry	20	6	N	Carex acu	46	19	41.30%
Calt.wet	1	2	P	Lych.flos.	49	41	83.67%
Calt.wet	1	6	P	Lych.flos.	63	59	93.65%
Calt.wet	1	2	P	Scirp.syl	51	51	100.00%
Calt.wet	1	6	P	Scirp.syl	64	62	96.88%
Calt.wet	1	2	P	Crepi.pal	50	0	0.00%
Calt.wet	1	6	P	Crepi.pal	48	1	2.08%
Calt.wet	1	2	P	Filip.ulm.	47	0	0.00%
Calt.wet	1	6	P	Filip.ulm.	39	2	5.13%
Calt.wet	1	2	P	Carex acu	46	11	23.91%
Calt.wet	1	6	P	Carex acu	41	22	53.66%
Calt.wet	2	2	A	Lych.flos.	48	40	83.33%
Calt.wet	2	6	A	Lych.flos.	54	47	87.04%
Calt.wet	2	2	A	Scirp.syl	48	41	85.42%
Calt.wet	2	6	A	Scirp.syl	55	54	98.18%
Calt.wet	2	2	A	Crepi.pal	48	0	0.00%
Calt.wet	2	6	A	Crepi.pal	46	0	0.00%
Calt.wet	2	2	A	Filip.ulm.	47	1	2.13%
Calt.wet	2	6	A	Filip.ulm.	51	4	7.84%
Calt.wet	2	2	A	Carex acu	51	18	35.29%
Calt.wet	2	6	A	Carex acu	39	27	69.23%
Calt.wet	3	2	F	Lych.flos.	49	38	77.55%
Calt.wet	3	6	F	Lych.flos.	48	44	91.67%
Calt.wet	3	2	F	Scirp.syl	60	56	93.33%
Calt.wet	3	6	F	Scirp.syl	70	70	100.00%
Calt.wet	3	2	F	Crepi.pal	48	1	2.08%
Calt.wet	3	6	F	Crepi.pal	47	0	0.00%
Calt.wet	3	2	F	Filip.ulm.	42	0	0.00%
Calt.wet	3	6	F	Filip.ulm.	45	1	2.22%
Calt.wet	3	2	F	Carex acu	48	19	39.58%
Calt.wet	3	6	F	Carex acu	48	19	39.58%
Calt.wet	4	2	F	Lych.flos.	51	34	66.67%
Calt.wet	4	6	F	Lych.flos.	50	47	94.00%
Calt.wet	4	2	F	Scirp.syl	58	58	100.00%
Calt.wet	4	6	F	Scirp.syl	46	46	100.00%
Calt.wet	4	2	F	Crepi.pal	40	3	7.50%
Calt.wet	4	6	F	Crepi.pal	47	0	0.00%
Calt.wet	4	2	F	Filip.ulm.	42	0	0.00%
Calt.wet	4	6	F	Filip.ulm.	37	0	0.00%
Calt.wet	4	2	F	Carex acu	49	21	42.86%
Calt.wet	4	6	F	Carex acu	45	6	13.33%
Calt.wet	5	2	K	Scirp.syl	46	46	100.00%
Calt.wet	5	6	K	Scirp.syl	48	48	100.00%
Calt.wet	5	2	K	Crepi.pal	48	0	0.00%
Calt.wet	5	6	K	Crepi.pal	48	0	0.00%
Calt.wet	5	2	K	Filip.ulm.	47	1	2.13%
Calt.wet	5	6	K	Filip.ulm.	47	1	2.13%
Calt.wet	5	2	K	Carex acu	48	25	52.08%
Calt.wet	5	6	K	Carex acu	46	20	43.48%
Calt.wet	6	2	A	Lych.flos.	51	29	56.86%
Calt.wet	6	6	A	Lych.flos.	49	45	91.84%
Calt.wet	6	2	A	Scirp.syl	63	56	88.89%
Calt.wet	6	6	A	Scirp.syl	49	49	100.00%
Calt.wet	6	2	A	Crepi.pal	51	0	0.00%
Calt.wet	6	6	A	Crepi.pal	47	0	0.00%
Calt.wet	6	2	A	Filip.ulm.	44	0	0.00%
Calt.wet	6	6	A	Filip.ulm.	46	0	0.00%
Calt.wet	6	2	A	Carex acu	52	17	32.69%
Calt.wet	6	6	A	Carex acu			
Calt.wet	7	2	N	Lych.flos.	49	23	46.94%
Calt.wet	7	6	N	Lych.flos.			

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Calt.wet	7	2	N	Scirp.syl	51	49	96.08%
Calt.wet	7	6	N	Scirp.syl	60	60	100.00%
Calt.wet	7	2	N	Crepi.pal	36	0	0.00%
Calt.wet	7	6	N	Crepi.pal	50	0	0.00%
Calt.wet	7	2	N	Filip.ulm.	50	0	0.00%
Calt.wet	7	6	N	Filip.ulm.	48	0	0.00%
Calt.wet	7	2	N	Carex acu	44	21	47.73%
Calt.wet	7	6	N	Carex acu	48	27	56.25%
Calt.wet	9	2	F	Lych.flos.	53	53	100.00%
Calt.wet	9	6	F	Lych.flos.	55	50	90.91%
Calt.wet	9	2	F	Scirp.syl	57	57	100.00%
Calt.wet	9	6	F	Scirp.syl			
Calt.wet	9	2	F	Crepi.pal	47	0	0.00%
Calt.wet	9	6	F	Crepi.pal	47	1	2.13%
Calt.wet	9	2	F	Filip.ulm.	47	2	4.26%
Calt.wet	9	6	F	Filip.ulm.	43	6	13.95%
Calt.wet	9	2	F	Carex acu	46	8	17.39%
Calt.wet	9	6	F	Carex acu	28	17	60.71%
Calt.wet	10	2	F	Lych.flos.	58	19	32.76%
Calt.wet	10	6	F	Lych.flos.	57	57	100.00%
Calt.wet	10	2	F	Scirp.syl	52	7	13.46%
Calt.wet	10	6	F	Scirp.syl	63	63	100.00%
Calt.wet	10	2	F	Crepi.pal	46	0	0.00%
Calt.wet	10	6	F	Crepi.pal	48	0	0.00%
Calt.wet	10	2	F	Filip.ulm.	43	0	0.00%
Calt.wet	10	6	F	Filip.ulm.	40	11	27.50%
Calt.wet	10	2	F	Carex acu	33	10	30.30%
Calt.wet	10	6	F	Carex acu	38	20	52.63%
Calt.wet	12	2	A	Lych.flos.	53	43	81.13%
Calt.wet	12	6	A	Lych.flos.	50	39	78.00%
Calt.wet	12	2	A	Scirp.syl	51	41	80.39%
Calt.wet	12	6	A	Scirp.syl	48	48	100.00%
Calt.wet	12	2	A	Crepi.pal	52	0	0.00%
Calt.wet	12	6	A	Crepi.pal	46	0	0.00%
Calt.wet	12	2	A	Filip.ulm.	42	0	0.00%
Calt.wet	12	6	A	Filip.ulm.	44	0	0.00%
Calt.wet	12	2	A	Carex acu	49	17	34.69%
Calt.wet	12	6	A	Carex acu	48	18	37.50%
Calt.wet	14	2	N	Lych.flos.	50	30	60.00%
Calt.wet	14	6	N	Lych.flos.	50	39	78.00%
Calt.wet	14	2	N	Scirp.syl	47	47	100.00%
Calt.wet	14	6	N	Scirp.syl	46	45	97.83%
Calt.wet	14	2	N	Crepi.pal	50	0	0.00%
Calt.wet	14	6	N	Crepi.pal	50	0	0.00%
Calt.wet	14	2	N	Filip.ulm.	40	3	7.50%
Calt.wet	14	6	N	Filip.ulm.	45	0	0.00%
Calt.wet	14	2	N	Carex acu	44	26	59.09%
Calt.wet	14	6	N	Carex acu	51	18	35.29%
Calt.wet	15	2	K	Lych.flos.	68	53	77.94%
Calt.wet	15	6	K	Lych.flos.	41	39	95.12%
Calt.wet	15	2	K	Scirp.syl	59	59	100.00%
Calt.wet	15	6	K	Scirp.syl	48	48	100.00%
Calt.wet	15	2	K	Crepi.pal	56	0	0.00%
Calt.wet	15	6	K	Crepi.pal	36	0	0.00%
Calt.wet	15	2	K	Filip.ulm.	40	0	0.00%
Calt.wet	15	6	K	Filip.ulm.	46	0	0.00%
Calt.wet	15	2	K	Carex acu	40	21	52.50%
Calt.wet	15	6	K	Carex acu	50	12	24.00%
Calt.wet	16	2	P	Lych.flos.	53	46	86.79%
Calt.wet	16	6	P	Lych.flos.	58	52	89.66%
Calt.wet	16	2	P	Scirp.syl	55	55	100.00%
Calt.wet	16	6	P	Scirp.syl	46	46	100.00%
Calt.wet	16	2	P	Crepi.pal	46	0	0.00%
Calt.wet	16	6	P	Crepi.pal	44	6	13.64%
Calt.wet	16	2	P	Filip.ulm.	47	0	0.00%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Calt.wet	16	6	P	Filip.ulm.			
Calt.wet	16	2	P	Carex acu	42	28	66.67%
Calt.wet	16	6	P	Carex acu	45	20	44.44%
Calt.wet	17	2	K	Lych.flos.	57	33	57.89%
Calt.wet	17	6	K	Lych.flos.	52	40	76.92%
Calt.wet	17	2	K	Scirp.syl	47	46	97.87%
Calt.wet	17	6	K	Scirp.syl	49	44	89.80%
Calt.wet	17	2	K	Crepi.pal	48	0	0.00%
Calt.wet	17	6	K	Crepi.pal	43	0	0.00%
Calt.wet	17	2	K	Filip.ulm.	48	0	0.00%
Calt.wet	17	6	K	Filip.ulm.	44	0	0.00%
Calt.wet	17	2	K	Carex acu	51	14	27.45%
Calt.wet	17	6	K	Carex acu	48	18	37.50%
Calt.wet	18	2	A	Lych.flos.			
Calt.wet	18	6	A	Lych.flos.	55	53	96.36%
Calt.wet	18	2	A	Crepi.pal	45	40	88.89%
Calt.wet	18	6	A	Crepi.pal	44	0	0.00%
Calt.wet	18	2	A	Filip.ulm.	46	0	0.00%
Calt.wet	18	6	A	Filip.ulm.	40	0	0.00%
Calt.wet	18	2	A	Scirp.syl	48	16	33.33%
Calt.wet	18	6	A	Scirp.syl	55	44	80.00%
Calt.wet	18	2	A	Carex acu	44	10	22.73%
Calt.wet	18	6	A	Carex acu	41	16	39.02%
Calt.wet	19	2	P	Lych.flos.	50	34	68.00%
Calt.wet	19	6	P	Lych.flos.	49	24	48.98%
Calt.wet	19	2	P	Scirp.syl	49	49	100.00%
Calt.wet	19	6	P	Scirp.syl	51	51	100.00%
Calt.wet	19	2	P	Crepi.pal	50	0	0.00%
Calt.wet	19	6	P	Crepi.pal	48	0	0.00%
Calt.wet	19	2	P	Filip.ulm.	45	0	0.00%
Calt.wet	19	6	P	Filip.ulm.	39	1	2.56%
Calt.wet	19	2	P	Carex acu	46	14	30.43%
Calt.wet	19	6	P	Carex acu	50	15	30.00%
Calt.wet	20	2	N	Lych.flos.	51	32	62.75%
Calt.wet	20	6	N	Lych.flos.	48	42	87.50%
Calt.wet	20	2	N	Scirp.syl	55	54	98.18%
Calt.wet	20	6	N	Scirp.syl	69	67	97.10%
Calt.wet	20	2	N	Crepi.pal	48	0	0.00%
Calt.wet	20	6	N	Crepi.pal	55	0	0.00%
Calt.wet	20	2	N	Filip.ulm.	47	0	0.00%
Calt.wet	20	6	N	Filip.ulm.	45	0	0.00%
Calt.wet	20	2	N	Carex acu	49	16	32.65%
Calt.wet	20	6	N	Carex acu	39	14	35.90%
Calt.wet	21	2	K	Lych.flos.	50	43	86.00%
Calt.wet	21	6	K	Lych.flos.	51	51	100.00%
Calt.wet	21	2	K	Scirp.syl			
Calt.wet	21	6	K	Scirp.syl	56	51	91.07%
Calt.wet	21	2	K	Crepi.pal	46	0	0.00%
Calt.wet	21	6	K	Crepi.pal	45	1	2.22%
Calt.wet	21	2	K	Filip.ulm.	44	5	11.36%
Calt.wet	21	6	K	Filip.ulm.	48	0	0.00%
Calt.wet	21	2	K	Carex acu	49	11	22.45%
Calt.wet	21	6	K	Carex acu			
Calt.wet	22	2	N	Lych.flos.	51	29	56.86%
Calt.wet	22	?	N	Lych.flos.	50	41	82.00%
Calt.wet	22	2	N	Scirp.syl	50	50	100.00%
Calt.wet	22	2	N	Crepi.pal	54	0	0.00%
Calt.wet	22	2	N	Filip.ulm.			
Calt.wet	22	2	N	Carex acu	46	18	39.13%
Calt.wet	23	2	P	Lych.flos.			
Calt.wet	23	6	P	Lych.flos.	52	33	63.46%
Calt.wet	23	2	P	Scirp.syl	52	4	7.69%
Calt.wet	23	6	P	Scirp.syl	42	42	100.00%
Calt.wet	23	2	P	Crepi.pal	50	46	92.00%
Calt.wet	23	6	P	Crepi.pal	48	0	0.00%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Calt.wet	23	2	P	Filip.ulm.	48	0	0.00%
Calt.wet	23	6	P	Filip.ulm.	45	0	0.00%
Calt.wet	23	2	P	Carex acu	49	8	16.33%
Calt.wet	23	6	P	Carex acu	50	13	26.00%
Caricion	1	2	P	Lych.flos	45	19	42.22%
Caricion	1	6	P	Lych.flos	49	25	51.02%
Caricion	1	2	P	Carex curt	36	31	86.11%
Caricion	1	6	P	Carex curt	50	44	88.00%
Caricion	1	2	P	Carex ech	50	48	96.00%
Caricion	1	6	P	Carex ech	47	47	100.00%
Caricion	1	2	P	Viola pal	52	31	59.62%
Caricion	1	6	P	Viola pal	51	22	43.14%
Caricion	1	2	P	Pot.pal	49	0	0.00%
Caricion	1	6	P	Pot.pal	51	0	0.00%
Caricion	2	2	A	Lych.flos	55	52	94.55%
Caricion	2	6	A	Lych.flos	50	28	56.00%
Caricion	2	2	A	Carex curt	48	48	100.00%
Caricion	2	6	A	Carex curt	50	50	100.00%
Caricion	2	2	A	Carex ech	53	53	100.00%
Caricion	2	6	A	Carex ech	48	48	100.00%
Caricion	2	2	A	Viola pal	46	32	69.57%
Caricion	2	6	A	Viola pal			
Caricion	2	2	A	Pot.pal	52	2	3.85%
Caricion	2	6	A	Pot.pal	44	0	0.00%
Caricion	3	2	F	Lych.flos	66	55	83.33%
Caricion	3	6	F	Lych.flos	33	20	60.61%
Caricion	3	2	F	Carex curt	40	40	100.00%
Caricion	3	6	F	Carex curt	50	46	92.00%
Caricion	3	2	F	Carex ech	53	53	100.00%
Caricion	3	6	F	Carex ech	51	51	100.00%
Caricion	3	2	F	Viola pal	54	38	70.37%
Caricion	3	6	F	Viola pal	52	32	61.54%
Caricion	3	2	F	Pot.pal	49	10	20.41%
Caricion	3	6	F	Pot.pal	48	3	6.25%
Caricion	4	2	F	Lych.flos	36	36	100.00%
Caricion	4	6	F	Lych.flos	48	24	50.00%
Caricion	4	2	F	Carex curt	47	43	91.49%
Caricion	4	6	F	Carex curt	48	45	93.75%
Caricion	4	2	F	Carex ech	48	48	100.00%
Caricion	4	6	F	Carex ech	48	46	95.83%
Caricion	4	2	F	Viola pal	53	48	90.57%
Caricion	4	6	F	Viola pal	49	37	75.51%
Caricion	4	2	F	Pot.pal	46	6	13.04%
Caricion	4	6	F	Pot.pal	48	0	0.00%
Caricion	5	2	K	Lych.flos	48	26	54.17%
Caricion	5	6	K	Lych.flos	36	22	61.11%
Caricion	5	2	K	Carex curt	48	46	95.83%
Caricion	5	6	K	Carex curt	46	46	100.00%
Caricion	5	2	K	Carex ech	53	53	100.00%
Caricion	5	6	K	Carex ech	50	49	98.00%
Caricion	5	2	K	Viola pal	50	8	16.00%
Caricion	5	6	K	Viola pal	49	39	79.59%
Caricion	5	2	K	Pot.pal	46	0	0.00%
Caricion	5	6	K	Pot.pal	49	2	4.08%
Caricion	6	2	A	Lych.flos	46	29	63.04%
Caricion	6	6	A	Lych.flos	46	26	56.52%
Caricion	6	2	A	Carex curt	45	45	100.00%
Caricion	6	6	A	Carex curt	49	47	95.92%
Caricion	6	2	A	Carex ech	51	50	98.04%
Caricion	6	6	A	Carex ech	50	50	100.00%
Caricion	6	2	A	Viola pal	52	29	55.77%
Caricion	6	6	A	Viola pal	54	28	51.85%
Caricion	6	2	A	Pot.pal	50	1	2.00%
Caricion	6	6	A	Pot.pal	56	1	1.79%
Caricion	7	2	N	Lych.flos	44	23	52.27%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Caricion	7	6	N	Lych.flos	46	34	73.91%
Caricion	7	2	N	Carex curt	48	48	100.00%
Caricion	7	6	N	Carex curt	44	41	93.18%
Caricion	7	2	N	Carex ech	46	45	97.83%
Caricion	7	6	N	Carex ech	47	47	100.00%
Caricion	7	2	N	Viola pal	50	42	84.00%
Caricion	7	6	N	Viola pal	49	43	87.76%
Caricion	7	2	N	Pot.pal	50	1	2.00%
Caricion	7	6	N	Pot.pal	47	22	46.81%
Caricion	8	2	F	Lych.flos	52	24	46.15%
Caricion	8	6	F	Lych.flos	50	14	28.00%
Caricion	8	2	F	Carex curt	50	44	88.00%
Caricion	8	6	F	Carex curt	50	48	96.00%
Caricion	8	2	F	Carex ech	48	48	100.00%
Caricion	8	6	F	Carex ech	48	48	100.00%
Caricion	8	2	F	Viola pal	53	36	67.92%
Caricion	8	6	F	Viola pal	47	15	31.91%
Caricion	8	2	F	Pot.pal	50	0	0.00%
Caricion	8	6	F	Pot.pal	46	0	0.00%
Caricion	9	2	F	Lych.flos	48	42	87.50%
Caricion	9	6	F	Lych.flos	45	45	100.00%
Caricion	9	2	F	Carex curt	49	46	93.88%
Caricion	9	6	F	Carex curt	48	47	97.92%
Caricion	9	2	F	Carex ech	51	51	100.00%
Caricion	9	6	F	Carex ech	44	43	97.73%
Caricion	9	2	F	Viola pal	50	42	84.00%
Caricion	9	6	F	Viola pal	46	46	100.00%
Caricion	9	2	F	Pot.pal	51	2	3.92%
Caricion	9	6	F	Pot.pal	47	9	19.15%
Caricion	10	2	A	Lych.flos	45	11	24.44%
Caricion	10	6	A	Lych.flos	53	24	45.28%
Caricion	10	2	A	Carex curt	47	46	97.87%
Caricion	10	6	A	Carex curt	48	46	95.83%
Caricion	10	2	A	Carex ech	47	45	95.74%
Caricion	10	6	A	Carex ech	52	52	100.00%
Caricion	10	2	A	Viola pal	48	48	100.00%
Caricion	10	6	A	Viola pal	52	52	100.00%
Caricion	10	2	A	Pot.pal	46	0	0.00%
Caricion	10	6	A	Pot.pal	42	2	4.76%
Caricion	11	2	N	Lych.flos	39	39	100.00%
Caricion	11	6	N	Lych.flos	39	20	51.28%
Caricion	11	2	N	Carex curt	51	45	88.24%
Caricion	11	6	N	Carex curt	51	45	88.24%
Caricion	11	2	N	Carex ech	54	49	90.74%
Caricion	11	6	N	Carex ech	54	54	100.00%
Caricion	11	2	N	Viola pal	47	47	100.00%
Caricion	11	6	N	Viola pal	47	41	87.23%
Caricion	11	2	N	Pot.pal	49	3	6.12%
Caricion	11	6	N	Pot.pal	49	0	0.00%
Caricion	12	2	P	Lych.flos	47	28	59.57%
Caricion	12	6	P	Lych.flos	46	19	41.30%
Caricion	12	2	P	Carex curt	47	45	95.74%
Caricion	12	6	P	Carex curt	49	49	100.00%
Caricion	12	2	P	Carex ech	47	44	93.62%
Caricion	12	6	P	Carex ech	54	54	100.00%
Caricion	12	2	P	Viola pal	49	35	71.43%
Caricion	12	6	P	Viola pal	53	25	47.17%
Caricion	12	2	P	Pot.pal	50	2	4.00%
Caricion	12	6	P	Pot.pal	45	2	4.44%
Caricion	13	2	K	Lych.flos	44	31	70.45%
Caricion	13	6	K	Lych.flos	49	15	30.61%
Caricion	13	2	K	Carex curt	47	47	100.00%
Caricion	13	6	K	Carex curt	44	44	100.00%
Caricion	13	2	K	Carex ech	56	56	100.00%
Caricion	13	6	K	Carex ech	53	53	100.00%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Caricion	13	2	K	Viola pal	52	32	61.54%
Caricion	13	6	K	Viola pal	46	15	32.61%
Caricion	13	2	K	Pot.pal	44	3	6.82%
Caricion	13	6	K	Pot.pal	47	4	8.51%
Caricion	14	2	A	Lych.flos	42	12	28.57%
Caricion	14	6	A	Lych.flos	47	37	78.72%
Caricion	14	2	A	Carex curt	49	37	75.51%
Caricion	14	6	A	Carex curt	44	19	43.18%
Caricion	14	2	A	Carex ech	49	49	100.00%
Caricion	14	6	A	Carex ech	47	47	100.00%
Caricion	14	2	A	Viola pal	50	49	98.00%
Caricion	14	6	A	Viola pal	54	37	68.52%
Caricion	14	2	A	Pot.pal	47	21	44.68%
Caricion	14	6	A	Pot.pal	49	2	4.08%
Caricion	15	2	P	Lych.flos	48	35	72.92%
Caricion	15	6	P	Lych.flos	44	33	75.00%
Caricion	15	2	P	Carex curt	52	48	92.31%
Caricion	15	6	P	Carex curt	36	32	88.89%
Caricion	15	2	P	Carex ech			
Caricion	15	6	P	Carex ech	49	49	100.00%
Caricion	15	2	P	Viola pal	51	38	74.51%
Caricion	15	6	P	Viola pal	52	36	69.23%
Caricion	15	2	P	Pot.pal	48	6	12.50%
Caricion	15	6	P	Pot.pal	44	5	11.36%
Caricion	16	2	N	Lych.flos	45	37	82.22%
Caricion	16	6	N	Lych.flos	53	53	100.00%
Caricion	16	2	N	Carex curt	48	45	93.75%
Caricion	16	6	N	Carex curt	48	48	100.00%
Caricion	16	2	N	Carex ech	50	41	82.00%
Caricion	16	6	N	Carex ech	52	52	100.00%
Caricion	16	2	N	Viola pal	45	41	91.11%
Caricion	16	6	N	Viola pal	52	52	100.00%
Caricion	16	2	N	Pot.pal	44	4	9.09%
Caricion	16	6	N	Pot.pal	42	42	100.00%
Caricion	17	2	K	Lych.flos	62	48	77.42%
Caricion	17	6	K	Lych.flos	43	40	93.02%
Caricion	17	2	K	Carex curt	48	46	95.83%
Caricion	17	6	K	Carex curt	48	46	95.83%
Caricion	17	2	K	Carex ech	47	47	100.00%
Caricion	17	6	K	Carex ech	50	50	100.00%
Caricion	17	2	K	Viola pal	56	42	75.00%
Caricion	17	6	K	Viola pal	47	38	80.85%
Caricion	17	2	K	Pot.pal	52	2	3.85%
Caricion	17	6	K	Pot.pal	49	1	2.04%
Caricion	18	2	N	Lych.flos	43	29	67.44%
Caricion	18	6	N	Lych.flos	48	17	35.42%
Caricion	18	2	N	Carex curt	50	45	90.00%
Caricion	18	6	N	Carex curt	50	50	100.00%
Caricion	18	2	N	Carex ech	52	50	96.15%
Caricion	18	6	N	Carex ech	54	54	100.00%
Caricion	18	2	N	Viola pal	53	44	83.02%
Caricion	18	6	N	Viola pal	49	42	85.71%
Caricion	18	2	N	Pot.pal	47	5	10.64%
Caricion	18	6	N	Pot.pal	49	3	6.12%
Caricion	19	2	K	Lych.flos	49	34	69.39%
Caricion	19	6	K	Lych.flos	50	24	48.00%
Caricion	19	2	K	Carex curt	51	43	84.31%
Caricion	19	6	K	Carex curt	48	44	91.67%
Caricion	19	2	K	Carex ech	52	52	100.00%
Caricion	19	6	K	Carex ech	46	46	100.00%
Caricion	19	2	K	Viola pal	51	50	98.04%
Caricion	19	6	K	Viola pal	49	41	83.67%
Caricion	19	2	K	Pot.pal	49	0	0.00%
Caricion	19	6	K	Pot.pal	45	5	11.11%
Caricion	20	2	P	Lych.flos	53	42	79.25%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Caricion	20	6	P	Lych.flos	53	44	83.02%
Caricion	20	2	P	Carex curt	50	48	96.00%
Caricion	20	6	P	Carex curt	44	44	100.00%
Caricion	20	2	P	Carex ech	47	39	82.98%
Caricion	20	6	P	Carex ech	52	50	96.15%
Caricion	20	2	P	Viola pal	49	37	75.51%
Caricion	20	6	P	Viola pal	54	43	79.63%
Caricion	20	2	P	Pot.pal	47	0	0.00%
Caricion	20	6	P	Pot.pal	42	0	0.00%
Magn.car	1	2	K	Lych.flos.	49	40	81.63%
Magn.Car	1	6	K	Lych.flos.	51	48	94.12%
Magn.Car	1	2	K	Carex nig	45	36	80.00%
Magn.Car	1	6	K	Carex nig	39	30	76.92%
Magn.Car	1	2	K	Pedicu.pal	49	31	63.27%
Magn.Car	1	6	K	Pedicu.pal	48	40	83.33%
Magn.Car	1	2	K	Seneci.aq	50	34	68.00%
Magn.Car	1	6	K	Seneci.aq	44	38	86.36%
Magn.Car	1	2	K	Ranuc.fla	47	19	40.43%
Magn.Car	1	6	K	Ranuc.fla	39	20	51.28%
Magn.Car	2	2	P	Lych.flos.	49	47	95.92%
Magn.Car	2	6	P	Lych.flos.	48	40	83.33%
Magn.Car	2	2	P	Carex nig	52	36	69.23%
Magn.Car	2	6	P	Carex nig	51	32	62.75%
Magn.Car	2	2	P	Pedicu.pal	46	43	93.48%
Magn.Car	2	6	P	Pedicu.pal	47	46	97.87%
Magn.Car	2	2	P	Seneci.aq	47	47	100.00%
Magn.Car	2	6	P	Seneci.aq	46	31	67.39%
Magn.Car	2	2	P	Ranuc.fla	41	19	46.34%
Magn.Car	2	6	P	Ranuc.fla	48	24	50.00%
Magn.Car	3	2	F	Lych.flos.	47	45	95.74%
Magn.Car	3	6	F	Lych.flos.	50	35	70.00%
Magn.Car	3	2	F	Carex nig	46	34	73.91%
Magn.Car	3	6	F	Carex nig	51	39	76.47%
Magn.Car	3	2	F	Pedicu.pal	34	22	64.71%
Magn.Car	3	6	F	Pedicu.pal	51	46	90.20%
Magn.Car	3	2	F	Seneci.aq	47	40	85.11%
Magn.Car	3	6	F	Seneci.aq	50	42	84.00%
Magn.Car	3	2	F	Ranuc.fla	36	14	38.89%
Magn.Car	3	6	F	Ranuc.fla	40	14	35.00%
Magn.Car	4	2	A	Lych.flos.	47	46	97.87%
Magn.Car	4	6	A	Lych.flos.	49	49	100.00%
Magn.Car	4	2	A	Carex nig	45	27	60.00%
Magn.Car	4	6	A	Carex nig	45	31	68.89%
Magn.Car	4	2	A	Pedicu.pal			
Magn.Car	4	6	A	Pedicu.pal	46	43	93.48%
Magn.Car	4	2	A	Seneci.aq	46	34	73.91%
Magn.Car	4	6	A	Seneci.aq	49	37	75.51%
Magn.Car	4	2	A	Ranuc.fla	50	21	42.00%
Magn.Car	4	6	A	Ranuc.fla	44	21	47.73%
Magn.Car	6	2	N	Lych.flos.	55	47	85.45%
Magn.Car	6	6	N	Lych.flos.	55	49	89.09%
Magn.Car	6	2	N	Carex nig	47	39	82.98%
Magn.Car	6	6	N	Carex nig	45	36	80.00%
Magn.Car	6	2	N	Pedicu.pal	47	47	100.00%
Magn.Car	6	6	N	Pedicu.pal	42	32	76.19%
Magn.Car	6	2	N	Seneci.aq	52	41	78.85%
Magn.Car	6	6	N	Seneci.aq	48	31	64.58%
Magn.Car	6	2	N	Ranuc.fla	52	21	40.38%
Magn.Car	6	6	N	Ranuc.fla	23	10	43.48%
Magn.Car	7	2	N	Lych.flos.	53	52	98.11%
Magn.Car	7	6	N	Lych.flos.	46	40	86.96%
Magn.Car	7	2	N	Carex nig	50	24	48.00%
Magn.Car	7	6	N	Carex nig	48	33	68.75%
Magn.Car	7	2	N	Pedicu.pal	34	29	85.29%
Magn.Car	7	6	N	Pedicu.pal	41	33	80.49%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Magn.Car	7	2	N	Seneci.aq	49	49	100.00%
Magn.Car	7	6	N	Seneci.aq	45	37	82.22%
Magn.Car	7	2	N	Ranuc.fla	45	25	55.56%
Magn.Car	7	6	N	Ranuc.fla	38	25	65.79%
Magn.Car	8	2	P	Lych.flos.	48	48	100.00%
Magn.Car	8	6	P	Lych.flos.	45	45	100.00%
Magn.Car	8	2	P	Carex nig	47	26	55.32%
Magn.Car	8	6	P	Carex nig	46	13	28.26%
Magn.Car	8	2	P	Pedicu.pal	43	42	97.67%
Magn.Car	8	6	P	Pedicu.pal	50	41	82.00%
Magn.Car	8	2	P	Seneci.aq	46	39	84.78%
Magn.Car	8	6	P	Seneci.aq	49	42	85.71%
Magn.Car	8	2	P	Ranuc.fla	38	14	36.84%
Magn.Car	8	6	P	Ranuc.fla	45	25	55.56%
Magn.Car	9	2	A	Lych.flos.	44	13	29.55%
Magn.Car	9	6	A	Lych.flos.	43	27	62.79%
Magn.Car	9	2	A	Carex nig	49	39	79.59%
Magn.Car	9	6	A	Carex nig	45	32	71.11%
Magn.Car	9	2	A	Pedicu.pal	53	47	88.68%
Magn.Car	9	6	A	Pedicu.pal	46	39	84.78%
Magn.Car	9	2	A	Seneci.aq	43	37	86.05%
Magn.Car	9	6	A	Seneci.aq	49	46	93.88%
Magn.Car	9	2	A	Ranuc.fla	44	16	36.36%
Magn.Car	9	6	A	Ranuc.fla	29	11	37.93%
Magn.Car	10	2	F	Lych.flos.	52	52	100.00%
Magn.Car	10	6	F	Lych.flos.	46	32	69.57%
Magn.Car	10	2	F	Carex nig	51	24	47.06%
Magn.Car	10	6	F	Carex nig	47	32	68.09%
Magn.Car	10	2	F	Pedicu.pal	43	42	97.67%
Magn.Car	10	6	F	Pedicu.pal	47	46	97.87%
Magn.Car	10	2	F	Seneci.aq	46	42	91.30%
Magn.Car	10	6	F	Seneci.aq	44	44	100.00%
Magn.Car	10	2	F	Ranuc.fla	38	19	50.00%
Magn.Car	10	6	F	Ranuc.fla	42	18	42.86%
Magn.Car	11	2	A	Lych.flos.	47	45	95.74%
Magn.Car	11	6	A	Lych.flos.	44	28	63.64%
Magn.Car	11	2	A	Carex nig	45	39	86.67%
Magn.Car	11	6	A	Carex nig	46	37	80.43%
Magn.Car	11	2	A	Pedicu.pal	49	41	83.67%
Magn.Car	11	6	A	Pedicu.pal	41	40	97.56%
Magn.Car	11	2	A	Seneci.aq	45	36	80.00%
Magn.Car	11	6	A	Seneci.aq	38	28	73.68%
Magn.Car	11	2	A	Ranuc.fla	46	27	58.70%
Magn.Car	11	6	A	Ranuc.fla	41	19	46.34%
Magn.Car	12	2	P	Lych.flos.	48	46	95.83%
Magn.Car	12	6	P	Lych.flos.	46	43	93.47%
Magn.Car	12	2	P	Carex nig	45	36	80.00%
Magn.Car	12	6	P	Carex nig	50	36	72.00%
Magn.Car	12	2	P	Pedicu.pal	50	41	82.00%
Magn.Car	12	6	P	Pedicu.pal	45	42	93.33%
Magn.Car	12	2	P	Seneci.aq	46	40	86.96%
Magn.Car	12	6	P	Seneci.aq	46	38	82.61%
Magn.Car	12	2	P	Ranuc.fla	35	26	74.29%
Magn.Car	12	6	P	Ranuc.fla	44	12	27.27%
Magn.Car	13	2	F	Lych.flos.	51	36	70.59%
Magn.Car	13	6	F	Lych.flos.	51	38	74.51%
Magn.Car	13	2	F	Carex nig	43	31	72.09%
Magn.Car	13	6	F	Carex nig	47	31	65.96%
Magn.Car	13	2	F	Pedicu.pal	46	44	95.65%
Magn.Car	13	6	F	Pedicu.pal	44	9	20.45%
Magn.Car	13	2	F	Seneci.aq	45	45	100.00%
Magn.Car	13	6	F	Seneci.aq	44	25	56.82%
Magn.Car	13	2	F	Ranuc.fla	35	13	37.14%
Magn.Car	13	6	F	Ranuc.fla	36	8	22.22%
Magn.Car	15	2	A	Lych.flos.	46	37	80.43%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Magn.Car	15	6	A	Lych.flos.	52	36	69.23%
Magn.Car	15	2	A	Carex nig			
Magn.Car	15	6	A	Carex nig	50	35	70.00%
Magn.Car	15	2	A	Pedicu.pal	40	40	100.00%
Magn.Car	15	6	A	Pedicu.pal	50	41	82.00%
Magn.Car	15	2	A	Seneci.aq	46	46	100.00%
Magn.Car	15	6	A	Seneci.aq	48	46	95.83%
Magn.Car	15	2	A	Ranuc.fla	22	8	36.36%
Magn.Car	15	6	A	Ranuc.fla	40	16	40.00%
Magn.Car	16	2	K	Lych.flos.	45	36	80.00%
Magn.Car	16	6	K	Lych.flos.	50	48	96.00%
Magn.Car	16	2	K	Carex nig	52	21	40.38%
Magn.Car	16	6	K	Carex nig	47	35	74.47%
Magn.Car	16	2	K	Pedicu.pal	44	43	97.73%
Magn.Car	16	6	K	Pedicu.pal	49	46	93.88%
Magn.Car	16	2	K	Seneci.aq	45	35	77.78%
Magn.Car	16	6	K	Seneci.aq	42	42	100.00%
Magn.Car	16	2	K	Ranuc.fla	39	30	76.92%
Magn.Car	16	6	K	Ranuc.fla	44	21	47.73%
Magn.Car	17	2	P	Lych.flos.	50	31	62.00%
Magn.Car	17	6	P	Lych.flos.	50	48	96.00%
Magn.Car	17	2	P	Carex nig	46	32	69.57%
Magn.Car	17	6	P	Carex nig	48	30	62.50%
Magn.Car	17	2	P	Pedicu.pal	47	31	65.96%
Magn.Car	17	6	P	Pedicu.pal	46	41	89.13%
Magn.Car	17	2	P	Seneci.aq	48	38	79.17%
Magn.Car	17	6	P	Seneci.aq	45	35	77.78%
Magn.Car	17	2	P	Ranuc.fla	35	16	45.71%
Magn.Car	17	6	P	Ranuc.fla	42	18	42.86%
Magn.Car	18	2	F	Lych.flos.	43	38	88.37%
Magn.Car	18	6	F	Lych.flos.	48	27	56.25%
Magn.Car	18	2	F	Carex nig	50	35	70.00%
Magn.Car	18	6	F	Carex nig	48	38	79.17%
Magn.Car	18	2	F	Pedicu.pal	42	39	92.86%
Magn.Car	18	6	F	Pedicu.pal	45	42	93.33%
Magn.Car	18	2	F	Seneci.aq	47	41	87.23%
Magn.Car	18	6	F	Seneci.aq	46	44	95.65%
Magn.Car	18	2	F	Ranuc.fla	36	18	50.00%
Magn.Car	18	6	F	Ranuc.fla	43	13	30.23%
Magn.Car	19	2	N	Lych.flos.	58	52	89.66%
Magn.Car	19	6	N	Lych.flos.	36	26	72.22%
Magn.Car	19	2	N	Carex nig	50	35	70.00%
Magn.Car	19	6	N	Carex nig	44	31	70.45%
Magn.Car	19	2	N	Pedicu.pal	43	37	86.05%
Magn.Car	19	6	N	Pedicu.pal	51	41	80.39%
Magn.Car	19	2	N	Seneci.aq	42	36	85.71%
Magn.Car	19	6	N	Seneci.aq	48	38	79.17%
Magn.Car	19	2	N	Ranuc.fla	34	16	47.06%
Magn.Car	19	6	N	Ranuc.fla	48	45	93.75%
Magn.Car	22	2	N	Lych.flos.	55	22	40.00%
Magn.Car	22	6	N	Lych.flos.	49	23	46.94%
Magn.Car	22	2	N	Carex nig	51	31	60.78%
Magn.Car	22	6	N	Carex nig	48	38	79.17%
Magn.Car	22	2	N	Pedicu.pal	47	47	100.00%
Magn.Car	22	6	N	Pedicu.pal	38	37	97.37%
Magn.Car	22	2	N	Seneci.aq	48	31	64.58%
Magn.Car	22	6	N	Seneci.aq	50	40	80.00%
Magn.Car	22	2	N	Ranuc.fla	42	11	26.19%
Magn.Car	22	6	N	Ranuc.fla	29	15	51.72%
Magn.Car	23	2	K	Lych.flos.	45	45	100.00%
Magn.Car	23	6	K	Lych.flos.	53	53	100.00%
Magn.Car	23	2	K	Carex nig	49	32	65.31%
Magn.Car	23	6	K	Carex nig			
Magn.Car	23	2	K	Pedicu.pal	44	42	95.45%
Magn.Car	23	6	K	Pedicu.pal	42	28	66.67%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Magn.Car	23	2	K	Seneci.aq	40	25	62.50%
Magn.Car	23	6	K	Seneci.aq	45	37	82.22%
Magn.Car	23	2	K	Ranuc.fla	43	18	41.86%
Magn.Car	23	6	K	Ranuc.fla	34	10	29.41%
Magn.Car	25	2	K	Lych.flos.			
Magn.Car	25	6	K	Lych.flos.	47	47	100.00%
Magn.Car	25	2	K	Carex nig			
Magn.Car	25	6	K	Carex nig			
Magn.Car	25	2	K	Pedicu.pal	45	40	88.89%
Magn.Car	25	6	K	Pedicu.pal	39	6	15.38%
Magn.Car	25	2	K	Seneci.aq	46	31	67.39%
Magn.Car	25	6	K	Seneci.aq	40	36	90.00%
Magn.Car	25	2	K	Ranuc.fla	33	18	54.55%
Magn.Car	25	6	K	Ranuc.fla	36	13	36.11%
Cen-Cyno	1	2	P	Lych.flos	50	19	38.00%
Cen-Cyno	1	6	P	Lych.flos	30	11	36.67%
Cen-Cyno	1	2	P	Carex hos	36	35	97.22%
Cen-Cyno	1	6	P	Carex hos	48	43	89.58%
Cen-Cyno	1	2	P	Carex flac	41	41	100.00%
Cen-Cyno	1	6	P	Carex flac	40	29	72.50%
Cen-Cyno	1	2	P	Pot.erecta	40	13	32.50%
Cen-Cyno	1	6	P	Pot.erecta	43	26	60.47%
Cen-Cyno	1	2	P	Filip. ulm.	45	20	44.44%
Cen-Cyno	1	6	P	Filip. ulm.	48	28	58.33%
Cen-Cyno	2	2	F	Lych.flos	42	26	61.90%
Cen-Cyno	2	6	F	Lych.flos	25	18	72.00%
Cen-Cyno	2	2	F	Carex hos	44	40	90.91%
Cen-Cyno	2	6	F	Carex hos	51	36	70.59%
Cen-Cyno	2	2	F	Carex flac	40	15	37.50%
Cen-Cyno	2	6	F	Carex flac	42	37	88.10%
Cen-Cyno	2	2	F	Pot.erecta	48	15	31.25%
Cen-Cyno	2	6	F	Pot.erecta	42	23	54.76%
Cen-Cyno	2	2	F	Filip. ulm.	46	12	26.09%
Cen-Cyno	2	6	F	Filip. ulm.	35	25	71.43%
Cen-Cyno	3	2	P	Lych.flos	45	20	44.44%
Cen-Cyno	3	6	P	Lych.flos	48	22	45.83%
Cen-Cyno	3	2	P	Carex hos	44	41	93.18%
Cen-Cyno	3	6	P	Carex hos	48	48	100.00%
Cen-Cyno	3	2	P	Carex flac	47	41	87.23%
Cen-Cyno	3	6	P	Carex flac	49	29	59.18%
Cen-Cyno	3	2	P	Pot.erecta	43	22	51.16%
Cen-Cyno	3	6	P	Pot.erecta	47	15	31.91%
Cen-Cyno	3	2	P	Filip. ulm.	35	24	68.57%
Cen-Cyno	3	6	P	Filip. ulm.	44	8	18.18%
Cen-Cyno	4	2	A	Lych.flos	29	24	82.76%
Cen-Cyno	4	6	A	Lych.flos	50	24	48.00%
Cen-Cyno	4	2	A	Carex hos	40	40	100.00%
Cen-Cyno	4	6	A	Carex hos	47	37	78.72%
Cen-Cyno	4	2	A	Carex flac	33	22	66.67%
Cen-Cyno	4	6	A	Carex flac	32	22	68.75%
Cen-Cyno	4	2	A	Pot.erecta	42	6	14.29%
Cen-Cyno	4	6	A	Pot.erecta	45	19	42.22%
Cen-Cyno	4	2	A	Filip. ulm.	38	5	13.16%
Cen-Cyno	4	6	A	Filip. ulm.	45	0	0.00%
Cen-Cyno	5	2	K	Lych.flos	47	2	4.26%
Cen-Cyno	5	6	K	Lych.flos	50	10	20.00%
Cen-Cyno	5	2	K	Carex hos	50	47	94.00%
Cen-Cyno	5	6	K	Carex hos	39	1	2.56%
Cen-Cyno	5	2	K	Carex flac	21	21	100.00%
Cen-Cyno	5	6	K	Carex flac	29	21	72.41%
Cen-Cyno	5	2	K	Pot.erecta	49	19	38.78%
Cen-Cyno	5	6	K	Pot.erecta	41	15	36.59%
Cen-Cyno	5	2	K	Filip. ulm.	41	2	4.88%
Cen-Cyno	5	6	K	Filip. ulm.	40	0	0.00%
Cen-Cyno	6	2	K	Lych.flos	44	27	61.36%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Cen-Cyno	6	6	K	Lych.flos	13	2	15.38%
Cen-Cyno	6	2	K	Carex hos	51	42	82.35%
Cen-Cyno	6	6	K	Carex hos	46	41	89.13%
Cen-Cyno	6	2	K	Carex flac	28	22	78.57%
Cen-Cyno	6	6	K	Carex flac	17	13	76.47%
Cen-Cyno	6	2	K	Pot.erecta	42	18	42.86%
Cen-Cyno	6	6	K	Pot.erecta	45	17	37.78%
Cen-Cyno	6	2	K	Filip. ulm.	48	17	35.42%
Cen-Cyno	6	6	K	Filip. ulm.	50	30	60.00%
Cen-Cyno	7	2	N	Lych.flos	50	12	24.00%
Cen-Cyno	7	6	N	Lych.flos	50	33	66.00%
Cen-Cyno	7	2	N	Carex hos	45	42	93.33%
Cen-Cyno	7	6	N	Carex hos	48	47	97.92%
Cen-Cyno	7	2	N	Carex flac	41	41	100.00%
Cen-Cyno	7	6	N	Carex flac	39	31	79.49%
Cen-Cyno	7	2	N	Pot.erecta	44	19	43.18%
Cen-Cyno	7	6	N	Pot.erecta	50	19	38.00%
Cen-Cyno	7	2	N	Filip. ulm.	40	32	80.00%
Cen-Cyno	7	6	N	Filip. ulm.	42	33	78.57%
Cen-Cyno	8	2	K	Lych.flos	47	6	12.77%
Cen-Cyno	8	6	K	Lych.flos	50	36	72.00%
Cen-Cyno	8	2	K	Carex hos	49	39	79.59%
Cen-Cyno	8	6	K	Carex hos	50	44	88.00%
Cen-Cyno	8	2	K	Carex flac	46	34	73.91%
Cen-Cyno	8	6	K	Carex flac	42	29	69.05%
Cen-Cyno	8	2	K	Pot.erecta	46	20	43.48%
Cen-Cyno	8	6	K	Pot.erecta	46	14	30.43%
Cen-Cyno	8	2	K	Filip. ulm.	42	1	2.38%
Cen-Cyno	8	6	K	Filip. ulm.	37	3	8.11%
Cen-Cyno	9	2	N	Lych.flos	50	6	12.00%
Cen-Cyno	9	6	N	Lych.flos	31	7	22.58%
Cen-Cyno	9	2	N	Carex hos	43	43	100.00%
Cen-Cyno	9	6	N	Carex hos	50	47	94.00%
Cen-Cyno	9	2	N	Carex flac	34	10	29.41%
Cen-Cyno	9	6	N	Carex flac	37	29	78.38%
Cen-Cyno	9	2	N	Pot.erecta	48	28	58.33%
Cen-Cyno	9	6	N	Pot.erecta	49	16	32.65%
Cen-Cyno	9	2	N	Filip. ulm.	40	1	2.50%
Cen-Cyno	9	6	N	Filip. ulm.	36	33	91.67%
Cen-Cyno	10	2	P	Lych.flos	34	28	82.35%
Cen-Cyno	10	6	P	Lych.flos	40	22	55.00%
Cen-Cyno	10	2	P	Carex hos	45	44	97.78%
Cen-Cyno	10	6	P	Carex hos	44	39	88.64%
Cen-Cyno	10	2	P	Carex flac	41	31	75.61%
Cen-Cyno	10	6	P	Carex flac	45	25	55.56%
Cen-Cyno	10	2	P	Pot.erecta	43	1	2.33%
Cen-Cyno	10	6	P	Pot.erecta	45	15	33.33%
Cen-Cyno	10	2	P	Filip. ulm.	38	37	97.37%
Cen-Cyno	10	6	P	Filip. ulm.	25	6	24.00%
Cen-Cyno	11	2	A	Lych.flos	33	31	93.94%
Cen-Cyno	11	6	A	Lych.flos	50	27	54.00%
Cen-Cyno	11	2	A	Carex hos	50	47	94.00%
Cen-Cyno	11	6	A	Carex hos	43	35	81.40%
Cen-Cyno	11	2	A	Carex flac	33	29	87.88%
Cen-Cyno	11	6	A	Carex flac	45	16	35.56%
Cen-Cyno	11	2	A	Pot.erecta	51	22	43.14%
Cen-Cyno	11	6	A	Pot.erecta	50	24	48.00%
Cen-Cyno	11	2	A	Filip. ulm.	41	32	78.05%
Cen-Cyno	11	6	A	Filip. ulm.	38	15	39.47%
Cen-Cyno	12	2	F	Lych.flos	50	21	42.00%
Cen-Cyno	12	6	F	Lych.flos	50	22	44.00%
Cen-Cyno	12	2	F	Carex hos	48	42	87.50%
Cen-Cyno	12	6	F	Carex hos	47	44	93.62%
Cen-Cyno	12	2	F	Carex flac	25	7	28.00%
Cen-Cyno	12	6	F	Carex flac	28	28	100.00%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Cen-Cyno	12	2	F	Pot.erecta	44	18	40.91%
Cen-Cyno	12	6	F	Pot.erecta	49	26	53.06%
Cen-Cyno	12	2	F	Filip. ulm.	45	29	64.44%
Cen-Cyno	12	6	F	Filip. ulm.	48	36	75.00%
Cen-Cyno	13	2	F	Lych.flos	50	3	6.00%
Cen-Cyno	13	6	F	Lych.flos	50	50	100.00%
Cen-Cyno	13	2	F	Carex hos	43	38	88.37%
Cen-Cyno	13	6	F	Carex hos	45	36	80.00%
Cen-Cyno	13	2	F	Carex flac	27	23	85.19%
Cen-Cyno	13	6	F	Carex flac	45	13	28.89%
Cen-Cyno	13	2	F	Pot.erecta	40	18	45.00%
Cen-Cyno	13	6	F	Pot.erecta	49	0	0.00%
Cen-Cyno	13	2	F	Filip. ulm.	45	7	15.56%
Cen-Cyno	13	6	F	Filip. ulm.	47	0	0.00%
Cen-Cyno	14	2	F	Lych.flos	48	20	41.67%
Cen-Cyno	14	6	F	Lych.flos	28	15	53.57%
Cen-Cyno	14	2	F	Carex hos	48	36	75.00%
Cen-Cyno	14	6	F	Carex hos	44	42	95.45%
Cen-Cyno	14	2	F	Carex flac	48	29	60.42%
Cen-Cyno	14	6	F	Carex flac	46	30	65.22%
Cen-Cyno	14	2	F	Pot.erecta	48	20	41.67%
Cen-Cyno	14	6	F	Pot.erecta	47	20	42.55%
Cen-Cyno	14	2	F	Filip. ulm.	39	27	69.23%
Cen-Cyno	14	6	F	Filip. ulm.	36	5	13.89%
Cen-Cyno	15	2	K	Lych.flos	40	2	5.00%
Cen-Cyno	15	6	K	Lych.flos	50	9	18.00%
Cen-Cyno	15	2	K	Carex hos	46	45	97.83%
Cen-Cyno	15	6	K	Carex hos	51	39	76.47%
Cen-Cyno	15	2	K	Carex flac	41	26	63.41%
Cen-Cyno	15	6	K	Carex flac	39	33	84.62%
Cen-Cyno	15	2	K	Pot.erecta	47	3	6.38%
Cen-Cyno	15	6	K	Pot.erecta	41	9	21.95%
Cen-Cyno	15	2	K	Filip. ulm.	45	38	84.44%
Cen-Cyno	15	6	K	Filip. ulm.	42	40	95.24%
Cen-Cyno	16	2	N	Lych.flos	50	12	24.00%
Cen-Cyno	16	6	N	Lych.flos	32	20	62.50%
Cen-Cyno	16	2	N	Carex hos	52	41	78.85%
Cen-Cyno	16	6	N	Carex hos	39	34	87.18%
Cen-Cyno	16	2	N	Carex flac	42	29	69.05%
Cen-Cyno	16	6	N	Carex flac	31	25	80.65%
Cen-Cyno	16	2	N	Pot.erecta	49	21	42.86%
Cen-Cyno	16	6	N	Pot.erecta	47	26	55.32%
Cen-Cyno	16	2	N	Filip. ulm.	40	11	27.50%
Cen-Cyno	16	6	N	Filip. ulm.	50	6	12.00%
Cen-Cyno	17	2	A	Lych.flos	50	18	36.00%
Cen-Cyno	17	6	A	Lych.flos	50	31	62.00%
Cen-Cyno	17	2	A	Carex hos	38	15	39.47%
Cen-Cyno	17	6	A	Carex hos	51	42	82.35%
Cen-Cyno	17	2	A	Carex flac	40	29	72.50%
Cen-Cyno	17	6	A	Carex flac	36	18	50.00%
Cen-Cyno	17	2	A	Pot.erecta	39	26	66.67%
Cen-Cyno	17	6	A	Pot.erecta	46	19	41.30%
Cen-Cyno	17	2	A	Filip. ulm.	48	26	54.17%
Cen-Cyno	17	6	A	Filip. ulm.	45	31	68.89%
Cen-Cyno	18	2	N	Lych.flos	38	16	42.11%
Cen-Cyno	18	6	N	Lych.flos	50	29	58.00%
Cen-Cyno	18	2	N	Carex hos	47	42	89.36%
Cen-Cyno	18	6	N	Carex hos	49	38	77.55%
Cen-Cyno	18	2	N	Carex flac	14	12	85.71%
Cen-Cyno	18	6	N	Carex flac	43	25	58.14%
Cen-Cyno	18	2	N	Pot.erecta	37	11	29.73%
Cen-Cyno	18	6	N	Pot.erecta	51	25	49.02%
Cen-Cyno	18	2	N	Filip. ulm.	42	39	92.86%
Cen-Cyno	18	6	N	Filip. ulm.	45	33	73.33%
Cen-Cyno	19	2	P	Lych.flos	50	17	34.00%

Appendix A: Germination data

Site	Plotnr	Quadr.nr	Treatment	Species	Before	After	%
Cen-Cyno	19	6	P	Lych.flos	41	15	36.59%
Cen-Cyno	19	2	P	Carex hos	45	45	100.00%
Cen-Cyno	19	6	P	Carex hos	51	46	90.20%
Cen-Cyno	19	2	P	Carex flac	42	37	88.10%
Cen-Cyno	19	6	P	Carex flac	42	20	47.62%
Cen-Cyno	19	2	P	Pot.erecta	44	9	20.45%
Cen-Cyno	19	6	P	Pot.erecta	44	18	40.91%
Cen-Cyno	19	2	P	Filip. ulm.	37	9	24.32%
Cen-Cyno	19	6	P	Filip. ulm.	40	10	25.00%
Cen-Cyno	20	2	A	Lych.flos	50	3	6.00%
Cen-Cyno	20	6	A	Lych.flos	28	28	100.00%
Cen-Cyno	20	2	A	Carex hos	47	42	89.36%
Cen-Cyno	20	6	A	Carex hos	46	41	89.13%
Cen-Cyno	20	2	A	Carex flac	44	0	0.00%
Cen-Cyno	20	6	A	Carex flac	21	21	100.00%
Cen-Cyno	20	2	A	Pot.erecta	42	16	38.10%
Cen-Cyno	20	6	A	Pot.erecta	46	12	26.09%
Cen-Cyno	20	2	A	Filip. ulm.	43	26	60.47%
Cen-Cyno	20	6	A	Filip. ulm.	44	3	6.82%

Appendix B: Statistical analysis of the results (germination percentages).

Statistical analysis of the germination percentages between the treatments within the species, after ARCSin-transformation: One-Way AOV (Df=4). P-value: $p < 0.05$ =*, $p < 0.01$=**, $p < 0.005$=***, $p < 0.0001$=****, $p > 0.05$=not significant (n.s.).

Site *	Species	p-Value	Significance
NEG9d	Lychnis flos- cuculi	0.3532	n.s.
	Scirpus sylvaticus	0.0000	****
	Anthoxantum odoratum	0.0122	*
	Filipendula ulmaria	0.0106	*
	Carex acutiformis	0.1702	n.s.
NEG9	Lychnis flos-cuculi	0.2442	n.s.
	Scirpus sylvaticus	0.2403	n.s.
	Crepis paludosa	0.0000	****
	Filipendula ulmaria	0.0000	****
	Carex acutiformis	0.8383	n.s.
NEG10	Lychnis flos-cuculi	0.0499	*
	Carex curta	0.9322	n.s.
	Carex echinata	0.0078	**
	Viola palustris	0.0092	**
	Potentilla palustris	0.0235	*
NEG11	Lychnis flos-cuculi	0.2403	n.s.
	Carex nigra	0.0002	***
	Pedicularis palustris	0.0730	n.s.
	Senecio aquatica	0.2103	n.s.
	Ranunculus flammula	0.3042	n.s.
GB4	Lychnis flos-cuculi	0.0247	*
	Carex hostiana	0.0016	***
	Carex flacca	0.5192	n.s.
	Potentilla erecta	0.4675	n.s.
	Filipendula ulmaria	0.2402	n.s.

Statistical analysis of the germination percentages between the treatments within the sites, after ARCSin-transformation: One-Way AOV (Df=4). P-value: $p < 0.05$=*, $p < 0.01$=**, $P < 0.005$=***, $p > 0.05$=not significant (n.s.).

Site	p-Value	Significance
NEG9D	0.9803	n.s.
NEG9	0.5491	n.s.
NEG10	0.6768	n.s.
NEG11	0.0224	*
GB4	0.7338	n.s.

Statistical analysis of the germination percentages between the species within the treatments, after ARCSin-transformation: One-Way AOV (Df=4). P-value: $p < 0.05$=*, $p < 0.01$=**, $p < 0.005$=***, $p < 0.0001$=****, $p > 0.05$=not significant (n.s.).

Treatment	p-Value	Significance
A	0.0000	****
N	0.0000	****
P	0.0000	****
K	0.0000	****
NPK	0.0000	****

Statistical analysis of the germination percentages between the species within the sites, after ARCSin-transformation: One-Way AOV (Df=4). P-value: $p < 0.05$-=*, $p < 0.01$=**, $p < 0.005$=***, $p < 0.0001$=****, $p > 0.05$=not significant (n.s.).

Site	p-Value	Significance
NEG9D	0.0000	****
NEG9	0.0000	****
NEG10	0.0000	****
NEG11	0.0000	****
GB4	0.0000	****

PART II:

Impact of canopy structure on seed germination and survival of selected semi-natural grassland species

or

"What is the fate of seedlings in the sward?"

Contents

Abstract

The aim of this project is to determine the impact of the canopy structure on the germination and survival of semi-natural grassland species. This is done by studying the germination of sown seeds of some selected species and the establishment of the seedlings under the influence of different canopy heights, irrigation and the presence or absence of gaps. Also the light quantity and quality reaching the seeds/seedlings were measured. Plots with a low canopy height had higher germination percentages than plots with a high canopy height. Disturbance and irrigation both had a positive influence on germination. The variables height of the canopy, disturbance and time and their interactions have significant effects on the light quality (red/ far red ratio) and quantity (PAR). The higher the vegetation, the lower the light quality and quantity at the base of the canopy. A disturbed canopy attenuates less light and therefore the light quality and quantity reaching the seed/ seedlings is higher in a undisturbed canopy. Irrigation only has an effect on the light quality: the light quality within irrigated plots is lower than the quality within non-irrigated plots.
The volumetric water content of the soil under the irrigated plots is, as could be expected, higher than the water content of the soil under the non-irrigated plots. However, there is no difference found in relative humidity within the swards of the different treated plots.

1. Introduction

1.1. General

The degradation of flora and vegetation in natural and semi-natural landscapes has become a matter of great concern. The problem affects the whole of western Europe as well as many other parts of the temperate world. This may be attributed to the dense population and the high level of technological development resulting in expanding towns, villages and industrial areas connected by a vast network of roads. Intensification of grassland management this century has resulted in enormous decreases in biological diversity within the farmed landscape (Baldock, 1990, see Sec. An. Report). The question is: "Is there a way back from degraded grassland to species-rich grassland communities?" (Bakker, 1989).

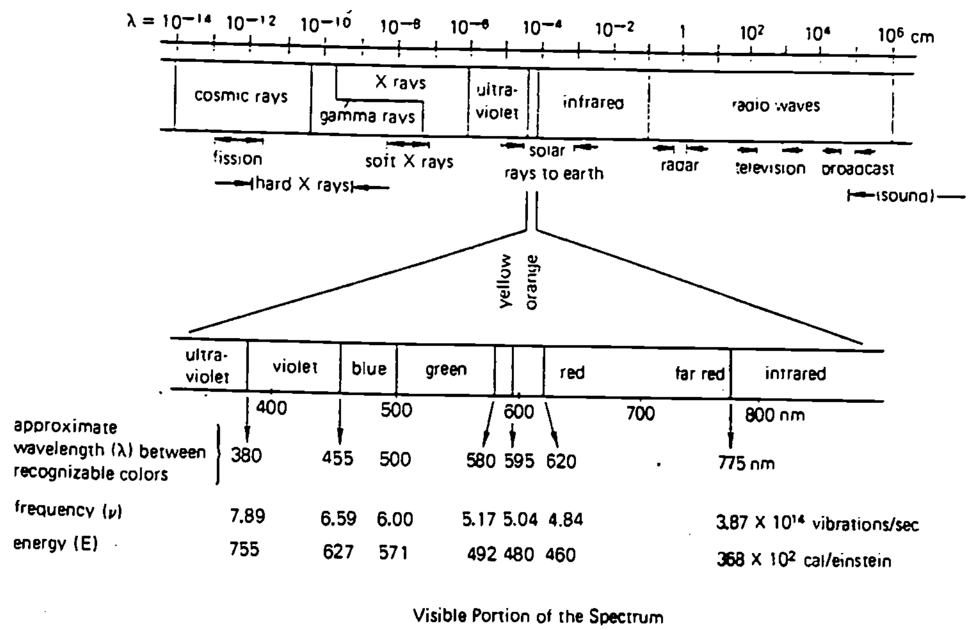
An EC-project (EGRO; see General Introduction) was set up in 1993 to establish methods to increase and maintain biological resources in extensively managed grasslands and to measure the impact of these managements on farm output and livelihood. One of the tasks of the EGRO-project is to identify the impact of differences in canopy structure on seed germination and establishment (Task 7, Sec. Ann. Report). This implies field experiments on "improved" and "unimproved" sites, studying the germination rate of sown seeds of some selected species and the establishment of the seedlings under the influence of soil tillage, irrigation and the presence or absence of gaps.
Isselstein (1994) set up laboratory and field experiments to examine the impact of water stress, soil disturbance and canopy presence on the germination and survival of selected wildflower species. He showed that the addition of water via irrigation and soil disturbance both had a major impact on subsequent seedling survival on either an unimproved or an improved grassland site. Competition by the existing sward was the main factor limiting seedling establishment. Competitive elimination of seedlings was much more severe in the improved grassland compared with the unimproved one.

Background

Regeneration from seeds in most communities is dependent upon the occurrence of gaps in the vegetation (Grubb, 1976 from Fenner, 1985).
Gaps provide conditions in which above ground competition is reduced or absent. Openings in the vegetation may be of almost any size and can arise naturally because of landslides, floods, fires, storms, or the activities of burrowing or trampling animals. The light, temperature and moisture regimes in such gaps are radically different from those in closed vegetation, and are dependent of the size of the gap (Fenner, 1985). It is possible that the shelter and humid conditions provided by the surrounding plants favours germination in small gaps, but in the long run the competition from the encroaching vegetation may reduce the chances of survival of

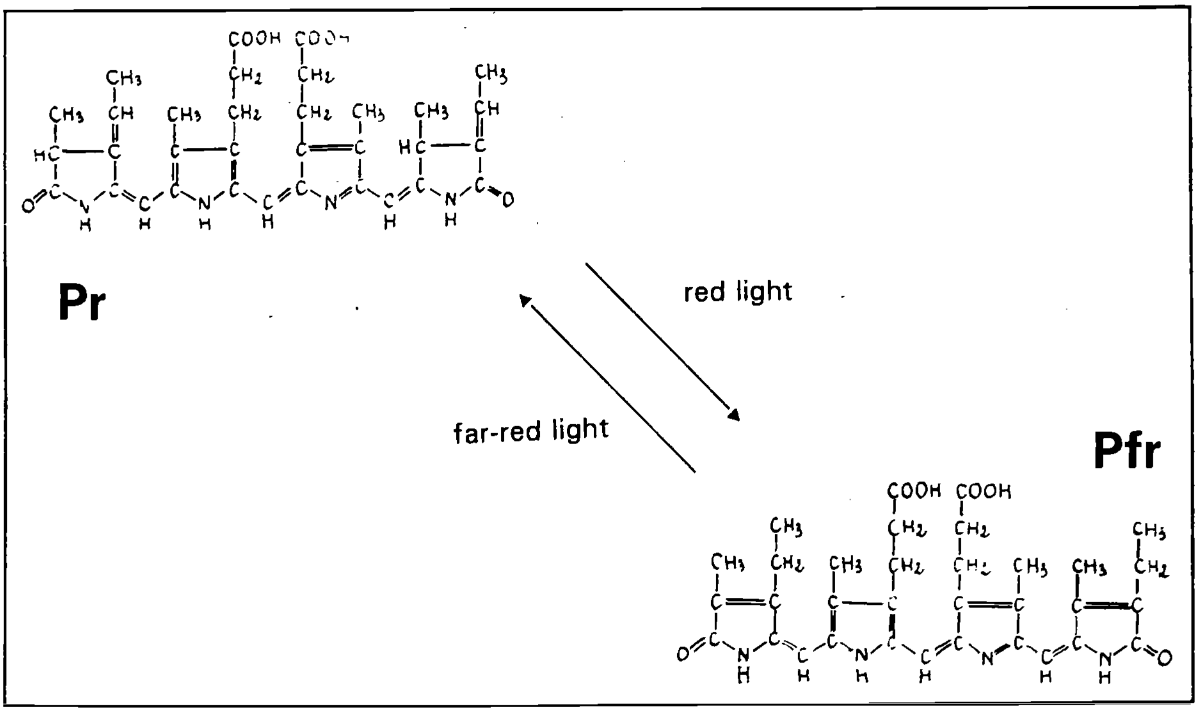
the seedlings there. An environmental feature which is apparently used by seeds for gap detection is light. Light is, in correct sense, the visible portion of the electromagnetic spectrum (Figure 1.1.1), (Salisbury & Ross, 1978). It is not clear wether plants utilize light quality or quantity as the more generally significant indicator of shade conditions (Holmes, 1983 from Hart, 1988). The largest changes in the light environments of terrestrial habitats are found under vegetation canopies. The radiation under canopies consists of two components:
(1) unfiltered solar radiation (both direct and diffuse) which has passed through gaps in the vegetation, and (2) filtered radiation which has passed through the vegetation and has been attenuated by the process of absorption, reflection and scattering. The combination of these two components, in varying proportions depending on the nature, structure, density and depth of the vegetation, determines the global below-canopy spectrum (Smith, 1982). The violet, blue, red and much of the green wavelengths are removed by leaves through photosynthesis and reflectance, but more of the far red passes through to the seeds below (Figure 1.1.1). The ratio of red to far red radiation is markedly reduced beneath a natural canopy (Salisbury & Ross, 1978). Over a hundred different responses of plants to red and far red radiation are known.

Figure 1.1.1: The electromagnetic spectrum using wavelength in cm. Various portions of the spectrum are shown, and the visible portion is expanded (Salisbury & Ross, 1978).



It seems that many aspects of plant behaviour are affected by these regions of the spectrum. The germination of many seeds is, for example, inhibited by light with a low red/far red ratio (Fenner, 1985). Casal et al. (1985, 1986) showed that a low red/ far red ratio reduces tillering and the number of mature buds that develop but it advances reproductive development by increasing the number of fertile tillers per plant and producing longer leaves, blades and reproductive shoots. However, the observation was always that the response of the plant was determined by the final irradiation. From this behaviour, it was postulated that the responses to red and far-red radiation were regulated by a single photochromic receptor: phytochrome. Phytochrome is distributed in most organs throughout all classes of green plants, including algae, mosses, ferns and gymnosperms (Salisbury & Ross, 1978). It is a photochromic pigment, which means it exists in two forms, and the photochemical reaction induced by the absorption of light converts phytochrome from one form to the other (Figure 1.1.2). The two forms of the pigment are known as Pr and Pfr and they have absorption maxima at λ 660 nm and λ 730 nm ; both forms also show significant absorption in the blue region of the spectrum (Figure 1.1.1). When Pr does absorb red light it is converted to Pfr, and, conversely, when Pfr absorbs far red light it is converted to Pr. It is generally believed that Pfr, which means a high red/ far red ratio, is the biologically active form. To describe certain natural light quality changes the ratio of the photon fluence rate in the red to that in the far red is often quoted (Smith, 1982). Another important factor in determining plant growth is the attenuation of PAR (Photosynthetically Active Radiation) within crop canopies where the PAR flux becomes limiting for photosynthesis.

Figure 1.1.2: The two forms of the photochromic receptor: phytochrome (Attridge, 1990).



Both the quality and quantity of light are important throughout the whole life cycle of the plant. The successful establishment of an angiosperm seedling may require light (or lack it) to break dormancy, to promote extension above the soil surface and to produce leaves of a size , shape, orientation and chlorophyll adequate for efficient photosynthesis. Seedling establishment involves subsequent development of the germinating seedling to a state where it no longer depends on stored nutrients, but can exist independently by using its own photosynthetic products. The early stages of seedling growth have high mortality rates. The main cause of death appeared to be desiccation (Silvertown and Dickie, 1981 from Fenner, 1985). Also burial and predation of the seedlings are major hazards. One of the most effective adaptations for ensuring successful seedling establishment is the possession of a large seed which provides an ample reserve of nutrients during the period immediately after germination. The large seeds found in species of dense vegetation probably represent an adaptation to establishment in shade. Even in grassland seedlings may last for many months in a state of inhibited development (Chippindale, 1948 from Fenner 1985). In these cases ample food reserves, coupled with shade tolerance and low growth rate are necessary for survival.

1.3. Project summer 1995

At first the aim of this project was to study the germination and survival of seeds of selected grassland species sowed in the sward of an improved and in an unimproved grassland. These grasslands, an extensively managed species-poor *Holco-Juncetum* rush pasture and an extensively managed species-rich *Cirsio-Molinietum,* were also used for field experiments by Isselstein (1994). He showed that competition by the existing sward was the main factor limiting seedling establishment. Competitive elimination of seedlings was much more severe in the improved grassland compared with the unimproved one. Because of the difference in canopy-structure between the two grasslands, the expectation was that this competitive elimination could be caused by competition for light. The idea was therefore to make a comparison between the seasonal changes in light attenuation by the canopy and the red/ far red ratio of light at ground level of the improved and the unimproved grassland. Because of lack of time it was not possible to do it all, so this project focuses only on the impact of canopy structure on seed germination and establishment on the improved grassland. The field experiments were took place on a "improved" (de-intensified) grassland site, studying the germination of sown seeds of selected semi-natural grassland species and the establishment of the seedlings under the influence of different canopy heights, irrigation and the presence or absence of gaps. Also the light quality and quantity reaching the base of the canopy is measured and the sward micro-climatic conditions are characterized by soil moisture content and relative humidity at ground level.

The hypotheses are:

H1: A higher canopy attenuates more light, in terms of Photosynthetic Active Radiation (PAR). So, the higher the canopy, the lower the germination and survival of the seed/seedlings.

H2: The quality of light, in terms of the red/ far red ratio, reaching the base of the canopy is lower in the plots with a higher vegetation.

H3: Irrigation and disturbance both have a positive effect on the germination and survival of the seeds/seedlings.

2. Materials and Methods

2.1. General procedure

To test the hypotheses, seed of semi-natural grassland species is sown in height controlled experimental plots. Each plot, with a controlled height, received a different combination of the treatments irrigation/ no irrigation and disturbance/ no disturbance. The germination and survival of the seeds/seedlings is followed throughout the season. Also the light quality and quantity reaching the base of the canopy is measured and the microclimatic conditions of the sward are characterized.

2.2. Description of the field site

The experimental site is located in central Devon near Okehampton (S.W. England, Figure 2.2.1). It is an extensively managed species-poor rush pasture on a non calcareous clay/stagnogley soil overlying impermeable clay/shale. The vegetation, classified according to Rodwell (1991), is a *Holco-Juncetum*. The pasture has received no inorganic fertilizers for fifteen years, and no organic manure during the past seven years. The site was very dry, especially this year with the extreme high temperatures during the summer. Table 2.2.1 presents the chemical composition of the soil (Tallowin, J.R.B., Isselstein, J., Smith, R.E.N. & Bedoret, H. 1994.).

Figure 2.2.1: Location of the experimental site in central Devon (Great Britain).

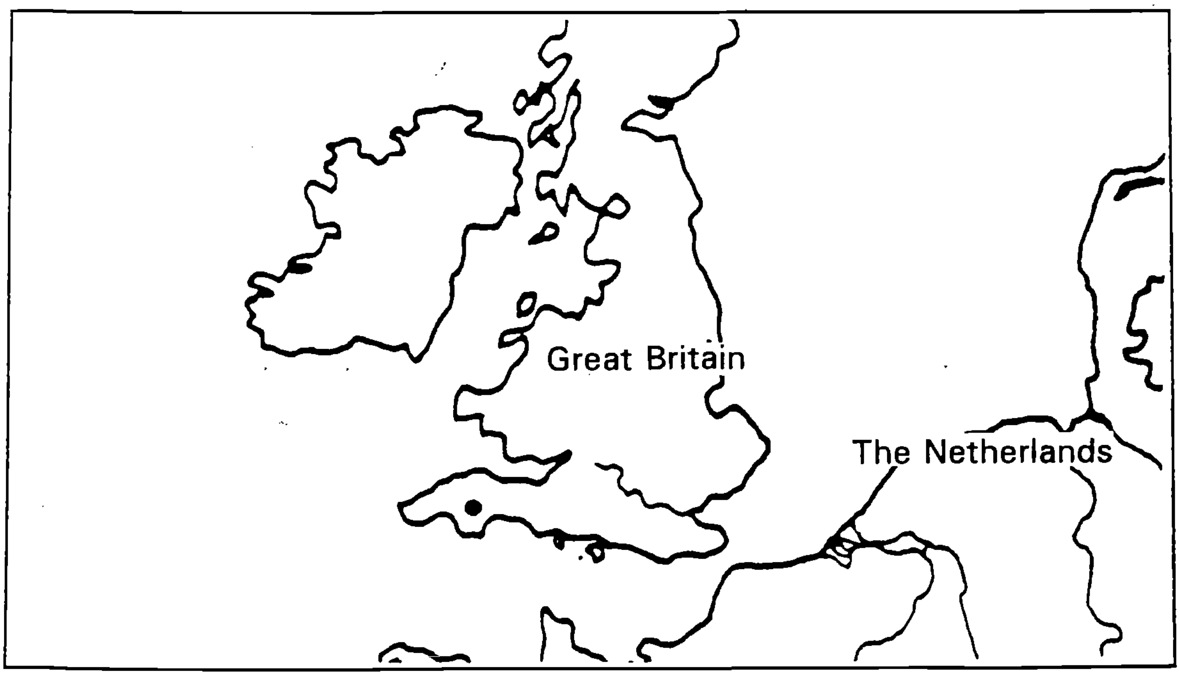


Table 2.2.1: Soil organic matter content (OM%), pH, bulk density (BD), extractable nitrogen (N_{ext}), total nitrogen (N%), total phosphorus (P%), total carbon (C%), exchangeable potassium (K), total calcium (Ca) amount, total carbon:nitrogen ratio (C:N), total carbon:phosphorus ratio (C:P) and total nitrogen:phosphorus ratio (N:P) at three depths (± s.e.)(Tallowin, J.R.B., Isselstein, J., Smith, R.E.N. & Bedoret, H. 1994.).

depth	0-5 cm	5-15 cm	15-30 cm
OM%	18.9 (1.38)	9.6 (0.61)	5.4 (0.045)
pH	5.5 (0.02)	5.5 (0.03)	6.1 (0.09)
BD (g/cm^3)	0.49 (0.127)	0.56 (0.088)	0.97 (0.048)
N_{ext} (kg/ha)	0.72 (0.138)	1.66 (0.433)	3.15 (0.570)
N%	0.68 (0.023)	0.42 (0.021)	0.34 (0.017)
P (mg/10g)	13.5 (0.55)	8.9 (0.33)	4.6 (0.53)
C%	6.92 (0.307)	3.85 (0.070)	2.13 (0.147)
K (mg/100g)	5.5 (0.49)	4.2 (0.84)	1.9 (0.15)
Ca (mg/100g)	15.8 (1.56)	13.5 (1.75)	13.9 (0.88)
C:N	10.2	9.2	6.9
C:P	51	43	46
N:P	5.0	4.7	7.4

2.3. Experimental procedure

An experiment with height controlled experimental plots (75*75 cm) was set up. On 3 April 1995 nitrogen (N) was applied at all plots at the rate of 50kg/ha. This was done to speed up the sward growth, to get the site ready in time. After the sward had reached a height over 30 cm the plots were treated with a growth retardant: 'Mefluidide' (02-05-'95). The rationale being to control the height of the sward. Marshall (1988) showed that mefluidide significantly retarded growth of a sward of mixed species; the effect lasted approximately 8 weeks.

During this experiment (1995) the vegetation started to grow again after only 4 weeks. From that time onwards the sward height was controlled by cutting the vegetation weekly by hand.

The experimental field contained 20 plots (replicated 3 times); each plot received a different combination of the following treatments (Figure 2.3.1):

1. The sward was cut at five different heights: 3, 7, 15, 22 and >30 cm.
2. Irrigation/ no irrigation; this was done by using an automatic controlled water system linked to leaky pipes looped around the experimental plots. The irrigated plots received water in 6 periods of 2 hours each a day.
3. Disturbance/ no disturbance; this was done by removing a core (length 10-15 cm), the size of a micro-plot (11 cm) and inverting it.

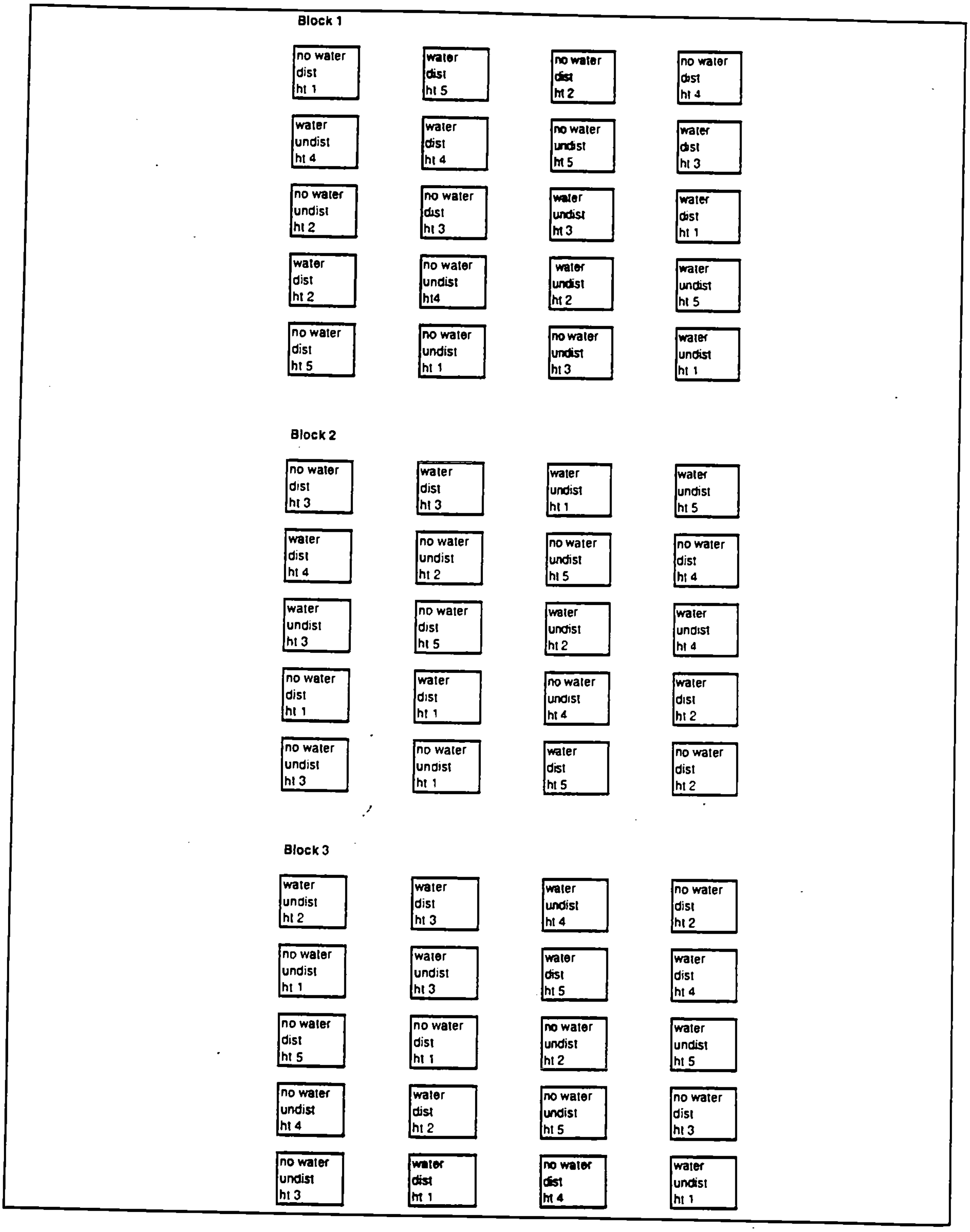
Mid July (13-14 July '95) 25 seeds of one of four semi-natural grassland species were sown separately on micro-plots (11 cm) on each plot (Figure 2.3.2). The sown species are:

Succisa pratensis
Cirsium dissectum
Molinea caerulea
Carex hostiana

The rationale being that these species are spring-germinators and key-species for semi-natural grasslands (for further details see Grime, 1988). The seeds used were hand collected in mid-Devon in 1994, except the *Cirsium dissectum* seeds which were collected in 1992.

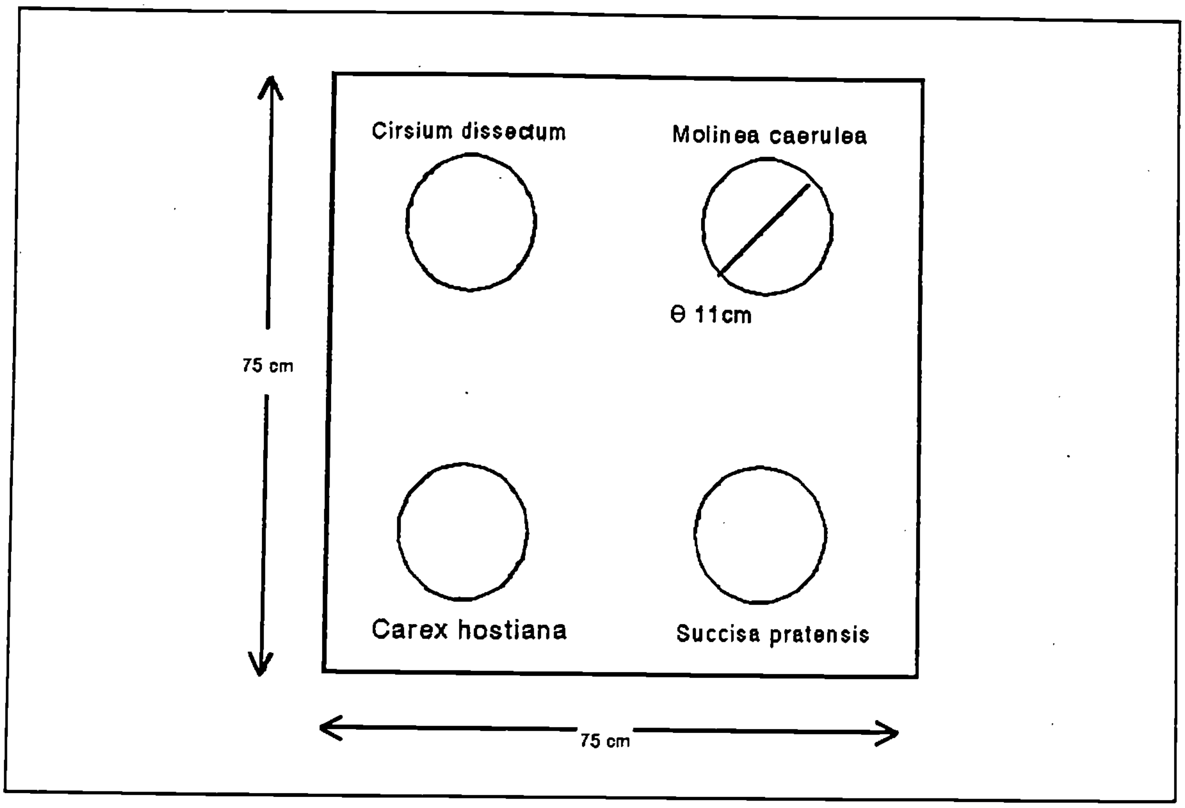
Before they were sown, the seeds of *Carex hostiana* and *Molinea caerulea* were stratified to enhance the rate and synchrony of germination (Isselstein, 1994). This stratification was done by spreading the seeds between moistened Whatman No.1 filter paper in a closed petri-dish and storing them at 4°C in the dark for 14 days. The seeds of *Succisa pratensis* were rolled in Benelate-dust to prevent rotting outside, during the experiment. The *Cirsium dissectum* seeds received no treatment.
To control the slugs, DOFF-Slugoids, containing 3% w/w Metaldehyde, were spread once every two or three weeks. The slugoids were scattered evenly around the perimeter of the plots in order to avoid their possible effects on seedling germination (Gange, Brown and Farmer, 1992).

Figure 2.3.1: Scheme of the experimental site with the 20*3=60 plots and their treatment.



* irrigation: water/ no water
* disturbance: disturbed(dist)/ undisturbed(undist)
* height: ht 1= 3 cm, ht 2= 7 cm, ht 3= 15 cm, ht 4= 22 cm, ht 5= >30cm

Figure 2.3.2: The four micro-plots with the four sown species within an experimental plot.



2.4. Measurements

* **The germination and survival** were measured at a 2-3 days interval by marking the germinated seedlings (per individual) to get a complete recording of emergence and survival. Other, unwanted seedlings were removed to exclude the competition factor. In the end of the season, the percentage germination and survival were calculated (Appendix A).

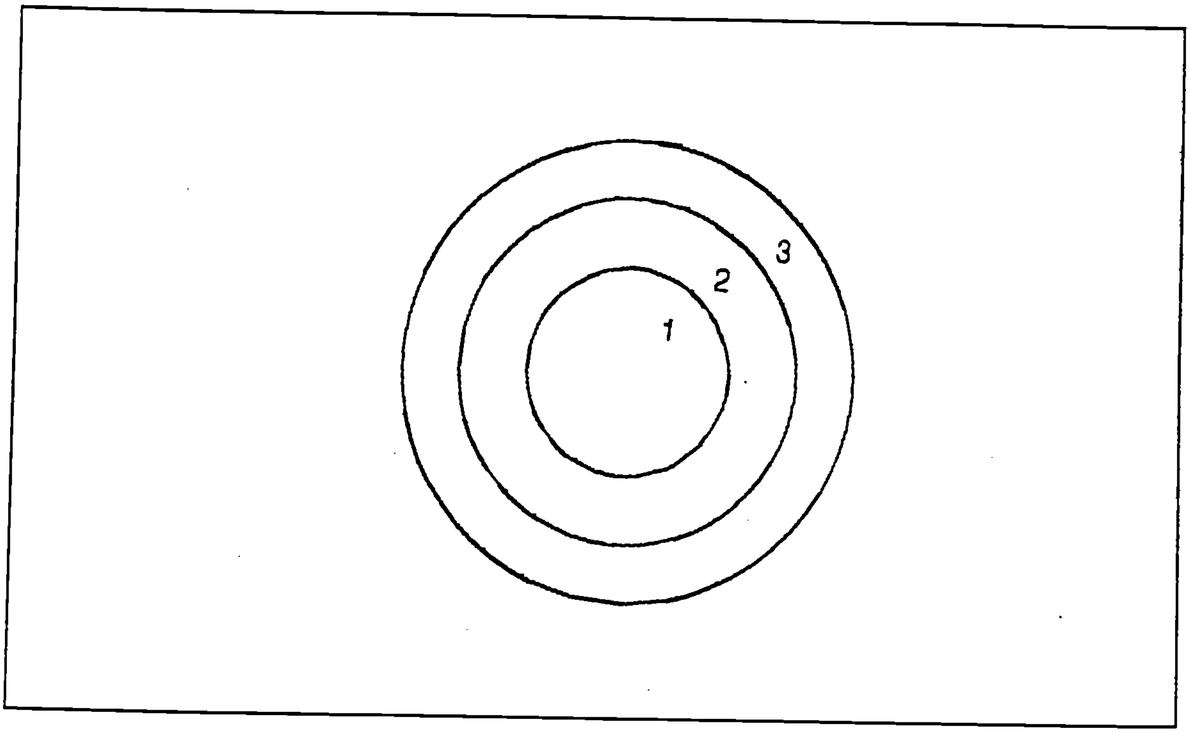
* **Light quantity(1) and quality(2)** on the height-controlled plots were measured twice in June and every week in August. Each combination of treatments was measured 30 (10*3 replicates) times to calculate the average and the standard deviation. The light was measured by using Skye light-meters which have a fibre optic cable to collect the light (Appendix B).
1. The PAR-light-meter measures the amount of μmols quanta/ m^2/ second from the Photosynthetically Active Region of the spectrum (400-700 nm) (Figure 1.1.1). The measurements were taken above and under the canopy to calculate the ratio (under/above) of the radiation that reached the base of the canopy.
2. The R:FR-light-meter measures the amount of μmols/ m^2/ second from the Red (660 nm) and the Far red (730 nm) region of the spectrum (Figure 1.1.1). To describe the light quality under the canopy the ratio of these two measurements was calculated.

* Sward micro-climatic conditions (**relative humidity(1)** and **volumetric water content of the soil(2)**) were monitored through out the summer in order to characterize the seed/seedling environment.
1. The relative humidity at ground level in percentages (%) was measured by using 'Tinytalk-RH Loggers'. Because of the limited number of loggers (10) a rotation system was set up during July and August to measure each treatment 3 times (replicates). The selected duration was 8 days and the measuring time interval was 6.4 minutes.
2. The soil water content in percentages was measured by using Time Domain Reflectrometry (TDR, Topp et al., 1980). The TDR-technique is an electromagnetic detection of soil moisture content; it uses dielectric properties of soils as a function of moisture content. The measurements were taken on a 7-14 days interval in the period from July till the end of August (Appendix C).

* In the end of the season **plant performance** was determined by measuring the number and the sizes (length and width) of the leaves of the seedlings. A plant performance-Index was calculated. The plant performance-indices were divided in three different classes from which the seedlings in the first class show the lowest performance and in the third class the highest performance.
The plant performance-Index for the dicotyl species *Cirsium dissectum* and *Succisa pratensis* was calculated as follow: Index D = (Length x Width x Number of leaves)/100. For the monocotyl species *Molinea caerulea* and *Carex hostiana* the width of the leaves was not measured and therefore Index M was calculated as (Length x Number of leaves)/10. The leaf areas were divided by 100 or 10 to get a 'readable' plant performance-Index.
The plant performance-index D for the dicotyl species was divided into three classes: Class 1: 0 - 5, Class 2: 6 - 10 and Class 3: > 10. The plant performance-index M for the monocotyl species was divided into the same classes. The Indices can not be compared due to the differences between the mono- and dicotyl species.

The position of the seedling in the micro-plot was determined by defining three circles within the micro-plot (Figure 2.4.1): centre(1), inner(2) and outer(3) circle. In the end of the season the circles in which the survived plants were situated were scored (Appendix D).

Figure 2.4.1: A micro-plot with the three circles: centre(1), inner(2) and outer(3) circle.



2.5. Data analysis

The data were stored in the computer by using the spreadsheet program microsoft-Excell, version 5.0. For the statistical analysis of the data the computer program SX-Statistix, version 4.0, was used. A general analysis of variance (ANOVA) was computed to examine the effect of the treatments (water/ no water, disturbance/ no disturbance and height, indirect light) and their interactions on the germination of the species. A pairwise comparison of means was done by using the Tukey (HSD)-test (rejection level 0.050). Before analyzing the data were ARCSin-transformed. Statistical analysis of the survival of the seeds was not possible, because of the limited number of data. The computer program SPSS/PC+, version 3.1, was used to do a two way ANOVA to analyze the differences in seasonal variation of light quality and quantity reaching the seeds/ seedlings between the different combinations of the treatments (irrigation and disturbance) and the different heights. These data were also ARCSin-transformed before analyzing. The figures presented in this report were made by using the programm Slide write, version 5.0.

3. Results

3.1. Germination

In table 3.1.1 the percentage germination of the four sown species are presented per treatment. The percentages are the calculated averages of the three replicates per treatment.

Table 3.1.1: Percentage germination per treatment during eleven weeks after sowing.

Treatment*			Cirsium dissectum	Molinea caerulea	Succisa pratensis	Carex hostiana
Hei	Wat	Dis				
3	-	-	1.3	0	0	0
7	-	-	6.7	0	2.7	0
15	-	-	9.4	0	0	0
22	-	-	4.0	0	0	0
>30	-	-	0	0	0	0
3	+	-	35.5	6.9	10.7	0
7	+	-	16.2	2.7	4.0	0
15	+	-	15.1	0	5.4	0
22	+	-	6.7	0	1.3	0
>30	+	-	0	0	0	0
3	+	+	39.7	16.1	9.4	0
7	+	+	29.2	10.8	9.4	0
15	+	+	27.1	10.7	8.1	0
22	+	+	31.5	19.6	8.0	0
>30	+	+	5.4	2.7	16.1	0
3	-	+	22.2	1.3	0	0
7	-	+	4.0	0	0	0
15	-	+	12.1	0	0	0
22	-	+	10.8	0	1.3	0
>30	-	+	0	0	5.4	0
mean			13.8	3.5	4.1	0

* Hei= height(cm), Wat= irrigation(+)/ no irrigation(-), Dis= disturbance(+)/ no disturbance(-)

Statistical analysis (General Analysis of Variance ANOVA) shows that there are significant differences in germination between the different species (Table 3.1.2). The data of *Carex hostiana* were not used in this analysis, because these seeds did not germinate at all during this experiment. *Cirsium dissectum* has the highest germination percentages, whereas *Molinea caerulea* has the lowest percentages.

Table 3.1.2: Statistical Analysis of Variance of the germination data, without the data of *Carex hostiana* (P-value: p<0.05=*, p<0.01=**, p<0.005=***, p<0.001=****, p<0.0005=*****, p<0.0001=******, p>0.05=not significant(n.s.)).

Variable	homogeneity					DF	p-Value	Significance
Disturbance (A)	Disturbed (a)		Undisturbed (b)			1	0.0001	*****
Height (B)	3cm (a)	7cm (ab)	15cm (ab)	22cm (ab)	30cm (b)	4	0.0014	***
Water (C)	Water (a)		No Water (b)			3	0.0000	******
Species * (D)	1 (a)	3 (b)	2 (b)			1	0.0000	******
A*B	-					4	0.6460	n.s.
A*D	-					1	0.2686	n.s.
B*D	-					4	0.0048	***
A*C	-					3	0.0109	*
B*C	-					12	0.0792	n.s.
C*D	-					3	0.0550	n.s.
A*B*D	-					4	0.6796	n.s.
A*B*C	-					12	0.3333	n.s.
A*C*D	-					3	0.7686	n.s.
B*C*D	-					12	0.7833	n.s.
A*B*C*D	-					12	0.8285	n.s.

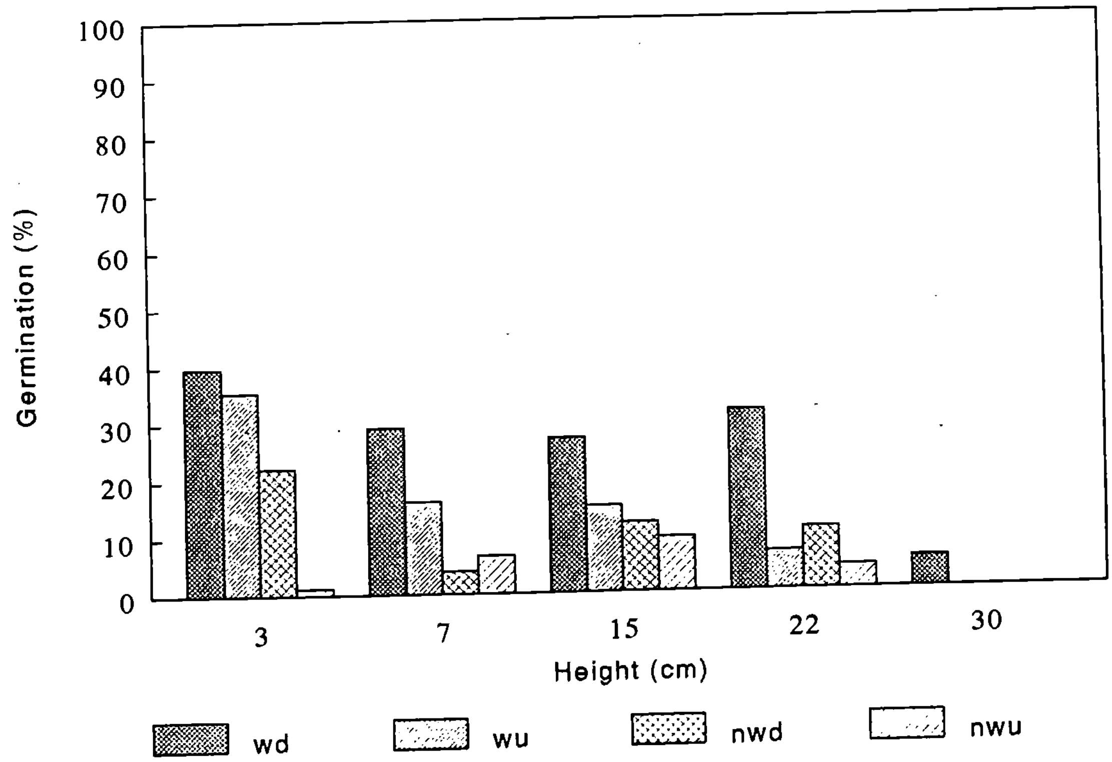
* species 1= *Cirsium dissectum*, species 2= *Molinea caerulea*, species 3= *Succisa pratensis*.

The analysis also shows that there are significant differences in germination between the different heights, between the irrigated and non-irrigated plots and between the disturbed and undisturbed plots over all the species. The plots with a canopy height of 3 (cm) have a significant higher germination percentage than the plots with a height of > 30 (cm). The irrigated plots have a significant higher germination than the non-irrigated plots, and the germination on the disturbed plots is also significantly higher than on the undisturbed plots. There also are some significant interaction effects: height x species and disturbance x water (Table 3.1.2). Only in the disturbed and irrigated plots, all species (except *Carex hostiana*) germinated in the plots with a height of >30 cm. *Succisa pratensis* also had some germination of the seeds in the >30 cm plots which were disturbed but not irrigated. The combination of irrigation and disturbance gives the highest germination percentages, whereas the combination of no irrigation and no disturbance gives the lowest germination percentages.

After testing over all species, an ANOVA was carried out per species to determine if there are significant differences in germination within the species:

For *Cirsium dissectum* there are overall significant differences in germination between the different heights, between the irrigated and non-irrigated plots and between the disturbed and undisturbed plots. There are no significant interaction effects. Because of the limited number of replicates (3) testing between the different treated plots gave no significant differences. Figure 3.1.1 shows the mean germination percentages per height.

Figure 3.1.1: Mean germination percentages per height for the different combination of treatments of *Cirsium dissectum*. (Water/ Disturbed (wd); Water/ Undisturbed (wu); No Water/ Disturbed (nwd); No Water/ Undisturbed (nwu)).



There are two groups of heights (3, 7, 15, 22 (cm) and 7, 15, 22, 30 (cm))in which the mean percentages are not significantly different from one another (Tukey (HSD) test; rejection level 0.050). This test also shows that the germination percentages are significantly higher in the disturbed plots than in the undisturbed plots and also higher in the irrigated plots than in the non-irrigated plots.

For *Molinea caerulea* there are no significant differences in germination between the different heights. But the germination is significantly higher on the disturbed plots compared to the undisturbed plots and on the irrigated plots compared to the non-irrigated plots. The interaction effect of these two treatments (disturbance x irrigation) is also significant. The plots which were disturbed and irrigated gave the highest germination percentages for all heights. The plots which were undisturbed and not irrigated had no germination at all.

For *Succisa pratensis* the results are more or less the same as those of *M. caerulea*: disturbance and irrigation give significant differences in germination.

Carex hostiana did not germinate at all.

In the end of August the amount of water the plots received per day was measured. This was done by putting the leaky pipes in a closed bucket for seven periods of 2 hours. The results showed that the plots in replicate 1 received 2.4 (l/day), the plots in replicate 2 received 0.5 (l/day) and the plots in replicate 3 received 5.3 (l/day). This large difference can be caused by a difference in water pressure of the leaky pipes. These pipes differed in length and in position (distance to the tap).

3.2 Survival

Table 3.2.1 presents the survival percentages of the emerged seeds per treatment eleven weeks after sowing. Because of the limited number of data no statistical analysis was possible. *Molinea caerulea* has the highest mean survival percentage, whereas *Cirsium dissectum* has the lowest mean survival percentage. The seeds of *Carex hostiana* did not germinate, so survival could not be measured.

Table 3.2.1: Percentage survival (% of emerged seedlings) per treatment eleven weeks after sowing.

Treatment*			Cirsium dissectum	Molinea caerulea	Succisa pratensis	Carex hostiana
Hei	Wat	Dis				
3	-	-	0	-	-	-
7	-	-	77.7	-	0	-
15	-	-	37.5	-	-	-
22	-	-	100	-	-	-
>30	-	-	-	-	-	-
3	+	-	42	66.7	75	-
7	+	-	25	100	54	-
15	+	-	50	-	-	-
22	+	-	50	-	100	-
>30	+	-	-	-	-	-
3	+	+	37.3	93.3	91.7	-
7	+	+	19	85.5	87.5	-
15	+	+	40	36.5	40	-
22	+	+	32.7	77	72.3	-
>30	+	+	0	0	41	-
3	-	+	76	100	-	-
7	-	+	100	-	-	-
15	-	+	58.5	-	-	-
22	-	+	78.5	-	0	-
>30	-	+	-	-	100	-
mean			48.5 (n=17)	69.9 (n=8)	60.1 (n=11)	-

* Hei = height (cm); Wat = irrigation(+)/no irrigation(-); Dis = disturbance(+)/no disturbance (-)

3.3. Light quality and quantity

The figures 3.3.1-4 show the percentages light quantity attenuation (PAR) per height and per combination of the treatments: irrigation and disturbance. Statistical analysis of variance shows that the light attenuation (PAR) is significantly different between the different heights and between the disturbed and undisturbed plots (Two-way ANOVA, $p<0.0001$). The higher the canopy, the higher the light attenuation, the lower the light quantity under the canopy. The disturbed plots have a lower light attenuation, and therefore a higher light quantity at the base of the canopy. There is also a significant difference in time. The interactions between these variables give also significantly differences in light attenuation.
Towards the end of the season the differences in light quantity attenuation between the different heights seem to decrease.

The figures 3.3.5-8 show the percentage light quality reaching the seeds/ seedlings, in terms of the red/ far red ratio, per height and per combination of the treatments: irrigation and disturbance. The variables height, irrigation, disturbance, time and their interactions give significant differences in light quality for all plots (Two-way ANOVA, $p< 0.0001$). The results are like those of the light quantity, with the exception of the variable irrigation. The irrigated plots have a lower red/ far red ratio and therefore a lower light quality at the base of the canopy. Maybe due to the irrigation the vegetation in the irrigated plots is denser and therefore absorbs more light. But when this is the case the expectation is that the irrigated plots also have a lower light quantity at the canopy base. This is not the case.
A striking point in all graphs is the 'dip' at 9-8-'95. There is no clear explanation for this, but it could be caused by weather conditions or technical device problems.
Also in these graphs the differences in light quality attenuation between the different heights seem to decrease towards the end of the season.

Figure 3.3.1: Percentages light quantity attenuation (PAR) per height for the treatment: No water/ Disturbed.

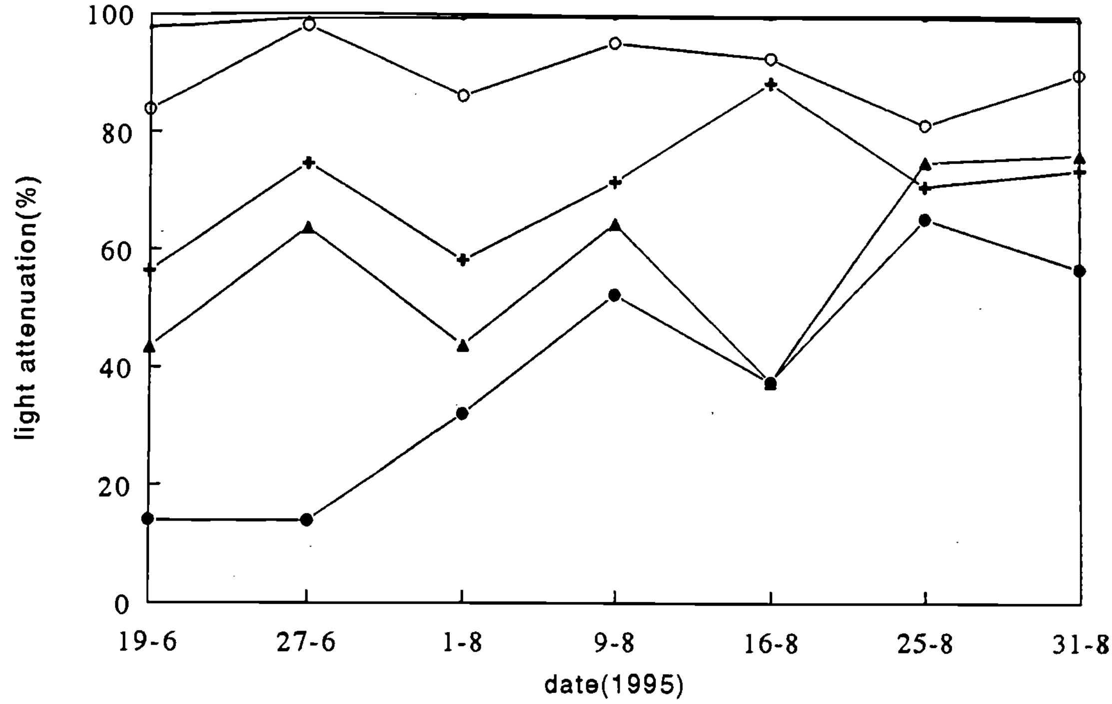


Figure 3.3.2: Percentage light quantity attenuation (PAR) per height for the treatment: No Water/ Undisturbed.

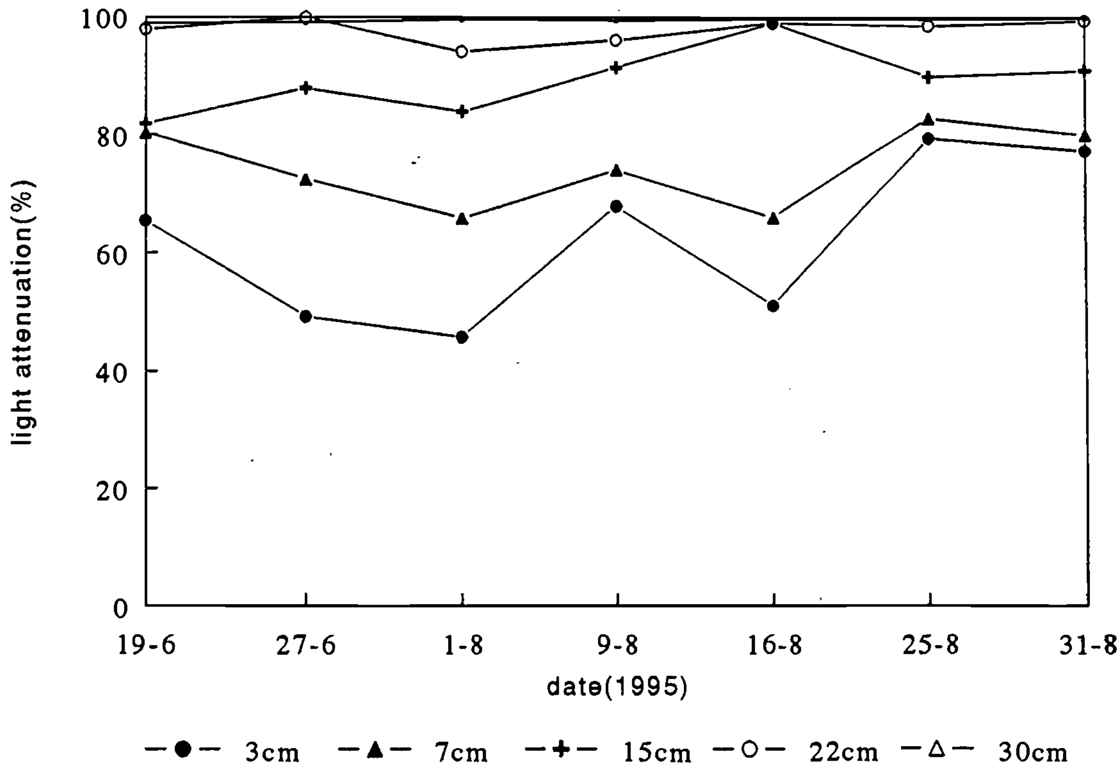


Figure 3.3.3: Percentage light quantity attenuation (PAR) per height for the treatment: Water/ Disturbed.

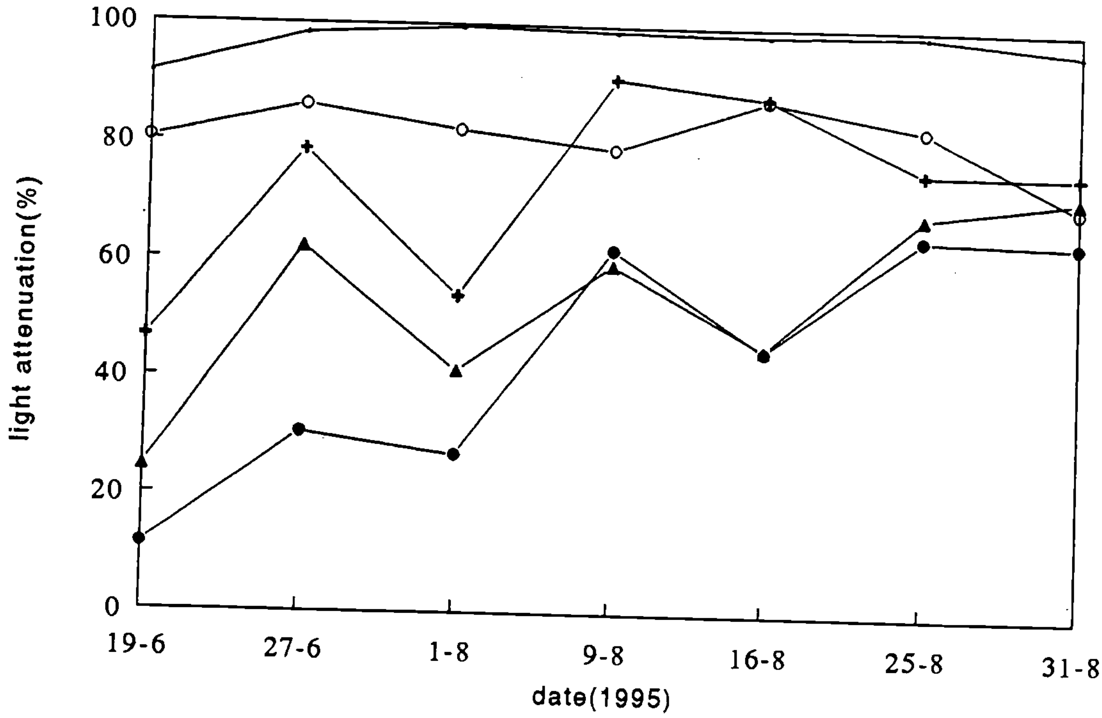


Figure 3.3.4: Percentage light quantity attenuation (PAR) per height for the treatment: Water/ Undisturbed.

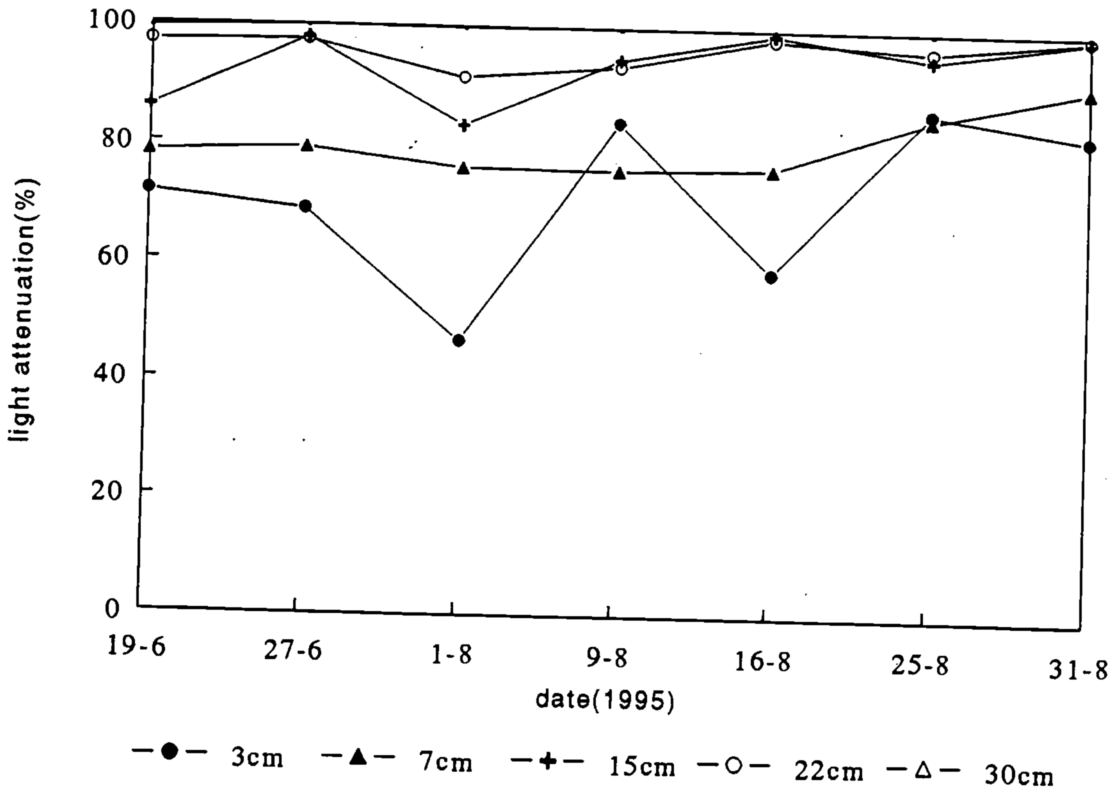


Figure 3.3.5: Percentages light quality attenuation (R:FR) per height for the treatment: No water/ Disturbed.

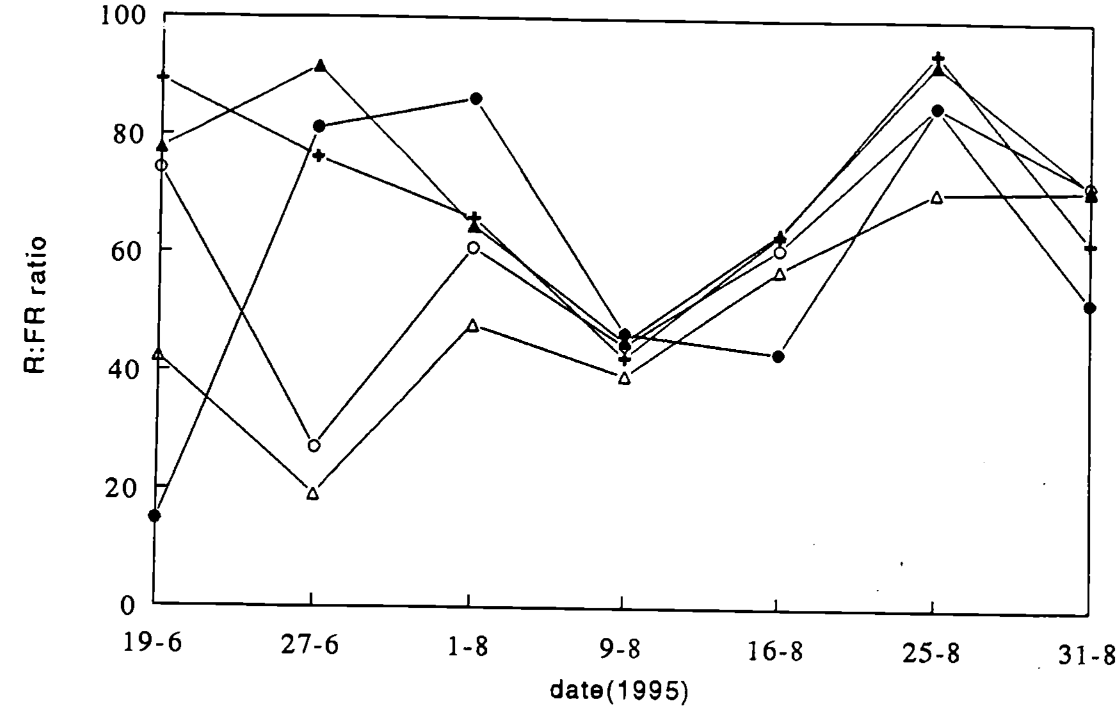
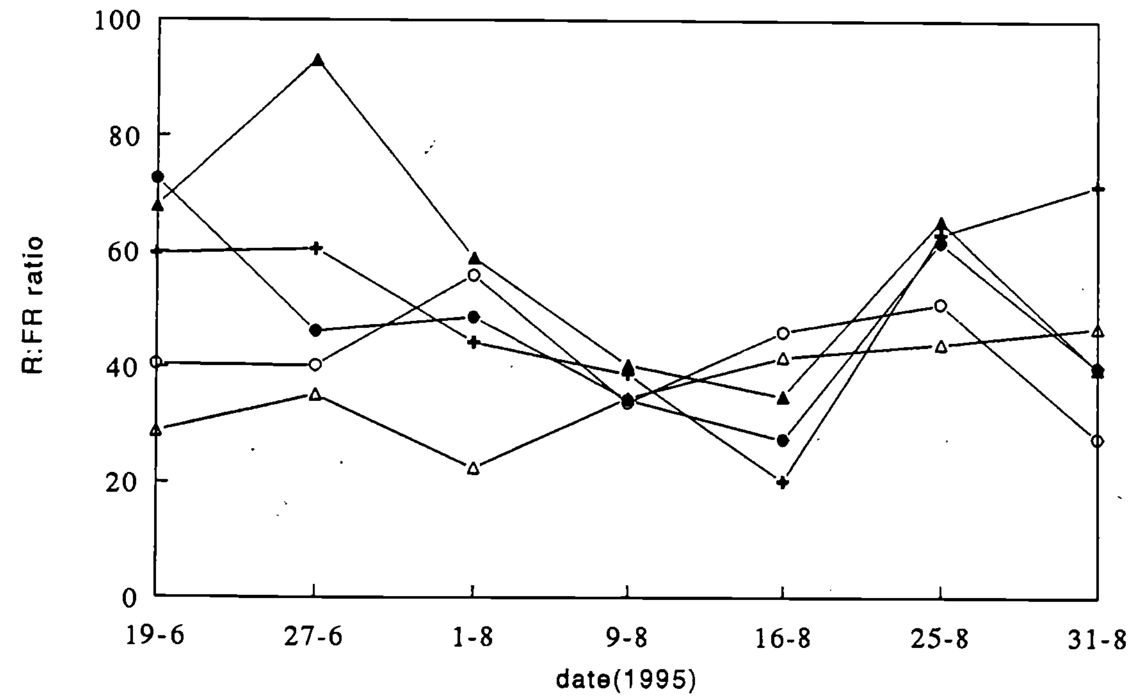


Figure 3.3.6: Percentages light quality attenuation (R:FR) per height for the treatment: No Water/ Undisturbed.



—●— 3cm —▲— 7cm —+— 15cm —○— 22cm —△— 30cm

Figure 3.3.7: Percentages light quality attenuation (R:FR) per height for the treatment: Water/ Disturbed.

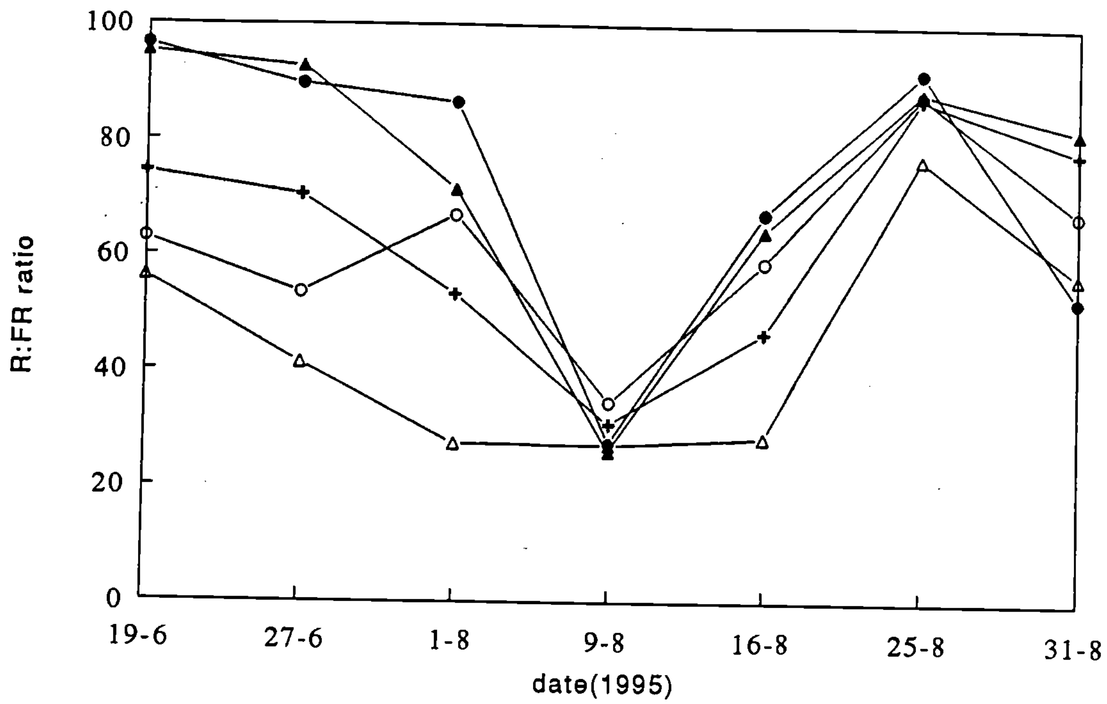
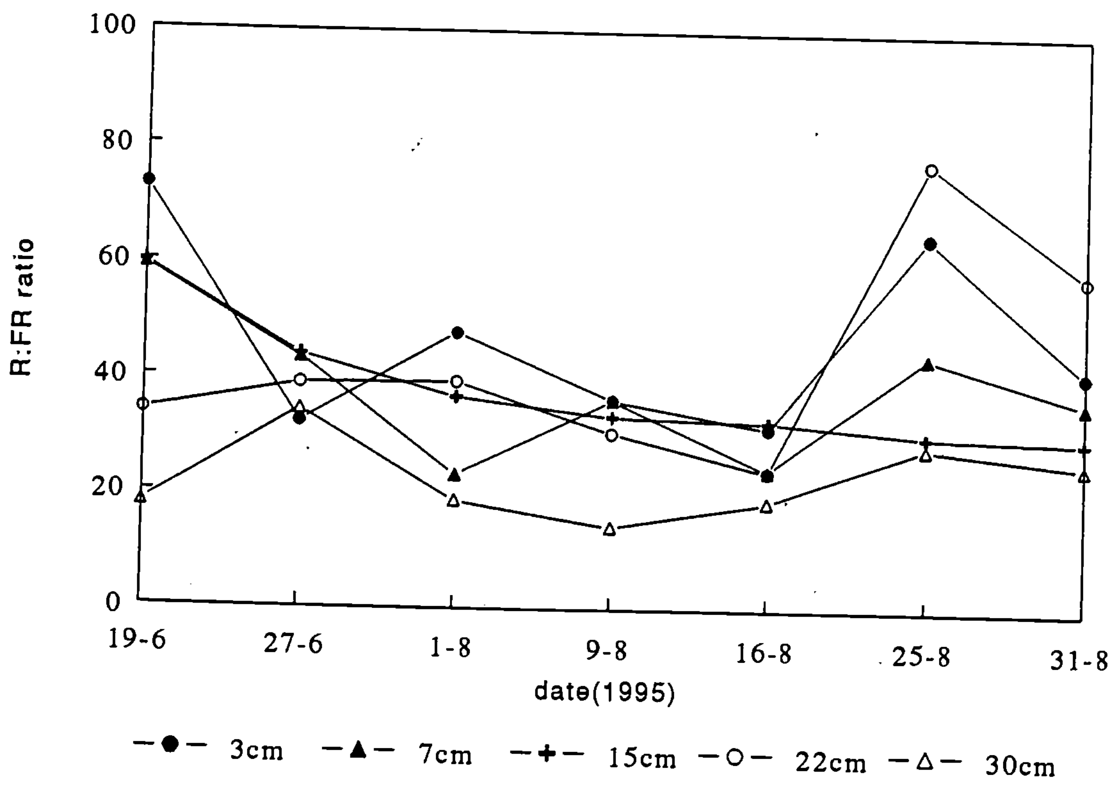


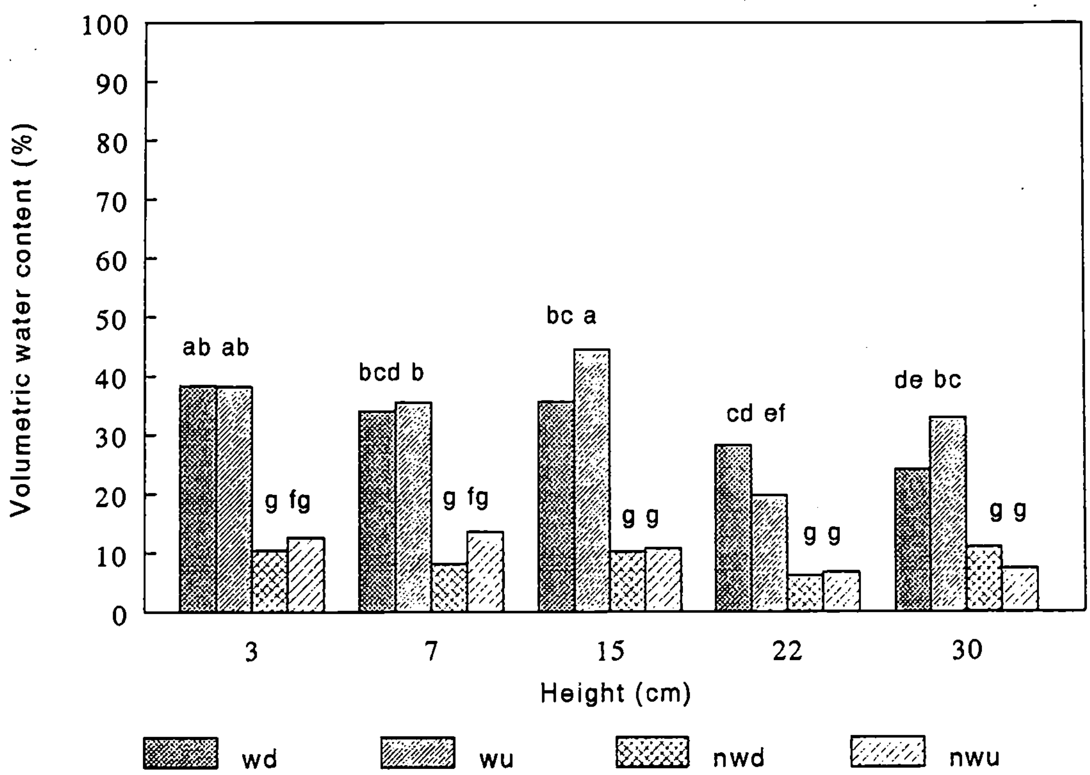
Figure 3.3.8: Percentages light quality attenuation (R:FR) per height for the treatment: Water/ Undisturbed.



3.4. Soil moisture content (TDR)

There is a difference in volumetric water content of the soil between the irrigated and non-irrigated plots (Figure 3.4.1) (One-Way AOV, $p < 0.0000$). The soils of the irrigated plots have a higher volumetric water content than the soils of the non-irrigated plots. The soil water content of the irrigated plots is significantly different between the disturbed and undisturbed plots within the heights 15, 22 and >30 cm (Figure 3.4.1).

Figure 3.4.1: Volumetric water content (%) per height per combination of treatments (Water/ Disturbed (wd); Water/ Undisturbed (wu); No Water/ Disturbed (nwd); No Water/ Undisturbed (nwu)). Any two bars which share the same letter are not significantly different from each other.



3.5 Relative humidity at ground level (Tiny-talks)

Table 3.5.1 presents the average relative humidity at ground level within the sward in percentages. There is no difference in humidity within the sward between the different treated plots (One-Way AOV, rejection level 0.050).

Table 3.5.1: The average relative humidity (%) at ground level per combination of treatments.

Height(cm)	Water	Disturbance	Rel. Humidity(%) (+/- s.d.)
3	-	-	81.64 (30.91)(n=3600)
7	-	-	87.12 (27.96)(n=5400)
15	-	-	85.49 (27.37)(n=5400)
22	-	-	77.73 (38.06)(n=5400)
>30	-	-	75.53 (40.15)(n=5400)
3	+	-	49.94 (45.78)(n=1800)
7	+	-	83.82 (31.96)(n=5400)
15	+	-	95.63 (11.80)(n=5400)
22	+	-	83.73 (33.02)(n=5400)
>30	+	-	76.41 (35.68)(n=5312)
3	+	+	92.63 (19.49)(n=5400)
7	+	+	92.76 (20.89)(n=5400)
15	+	+	86.24 (25.90)(n=5400)
22	+	+	85.31 (27.36)(n=5400)
>30	+	+	76.76 (26.88)(n=5400)
3	-	+	91.81 (17.76)(n=5400)
7	-	+	91.63 (20.93)(n=5400)
15	-	+	86.70 (27.23)(=5400)
22	-	+	79.12 (36.33)(n=3600)
>30	-	+	92.14 (19.52)(n=5400)

* Water= irrigation (+)/ no irrigation (-); Disturbance= disturbance (+)/ no disturbance (-)

3.6 Plant performance

The number of leaves, the length and width of the largest leaf is measured per survived seedling and the position of the seedlings in the micro-plot is determined (Appendix D).
The number and performance of survived seedlings of the dicotyl species *Cirsium dissectum* and *Succisa pratensis* (Index D) and of the monocotyl species *Molinea caerulea* (Index M) are listed in table 3.6.1 (the seeds of *Carex hostiana* did not germinate at all). The plant performance-indexes (D and M) are divided in three different classes from which the seedlings in the first class show the lowest performance and in the third class the highest performance (Materials and Methods). Also the position in the micro-plot of these survived seedlings are listed in this table.

The survived seedlings from *Cirsium dissectum* and *Succisa pratensis* are mainly found in the outer circle of the micro-plots (position 3), whereas the seedling of *Molinea caerulea* mostly are found in the inner circle of the micro-plots (position 2).
From the species *Molinea caerulea* and *Succisa pratensis* the survived seedlings were all situated in irrigated plots, whereas the seedlings from *Cirsium dissectum* were situated in irrigated and non-irrigated plots. The seedlings of all three species are occurring in disturbed and undisturbed micro-plots with different heights.
The performance-index D of *Succisa pratensis* seedlings is low, all are classified as 1, whereas the seedlings of *Cirsium dissectum* are occurring in all three classes. The seedlings of *Molinea caerulea* are showing a performance-index M of class 2.
Almost all seedlings which have the highest classification (3) are situated in the irrigated and disturbed plots. The Indices can not be compared due to the differences between the mono- and dicotyl species. These results are not tested on significance due to the low number of survived seedlings.

Table 3.6.1: The number of seedlings per position and performance of those seedlings is given per treatment per species. The performance-index M and D are given in three different classes from which the third class shows the highest performance.

Treatment *			Cirsium dissectum		Succisa pratensis		Molinea caerulea	
Hei	Wat	Dis	Position 1 2 3	Index D **	Position 1 2 3	Index D **	Position 1 2 3	Index M **
3	-	-	- - 1	1	- - -	-	- - -	-
7	-	-	- - 2	1	- - -	-	- - -	-
15	-	-	- - 1	1	- - -	-	- - -	-
22	-	-	- - -	-	- - -	-	- - -	-
>30	-	-	- - -	-	- - -	-	- - -	-
3	+	-	1 - 4	1	- 1 8	1	- - 1	2
7	+	-	- - 5	1	- 2 -	1	- - -	-
15	+	-	- 2 1	1	2 2 -	1	- - -	-
22	+	-	- - -	-	- - -	-	- - -	-
>30	+	-	- - -	-	- - -	-	- - -	-
3	+	+	- 4 10	2	1 2 3	1	1 5 4	2
7	+	+	2 5 -	2	1 1 4	1	1 5 -	2
15	+	+	- 1 4	3	- - -	-	2 1 -	2
22	+	+	2 2 5	2	- - 1	1	3 6 1	3
>30	+	+	- - -	-	2 - -	1	- - -	-
3	-	+	4 9 -	1	- - -	-	- - -	-
7	-	+	- - -	1	- - -	-	- - -	-
15	-	+	- 1 -	3	- - -	-	- - -	-
22	-	+	3 2 1	1	- - -	-	- - -	-
>30	-	+	- - -	-	- - -	-	- - -	-

* Treatments: Hei= height (cm), Wat= irrigation (+)/non irrigation (-), Dis= disturbance (+)/no disturbance (-)
** Performance-Index D and Index-M divided in Class: 1 = 0-5, 2 = 6-10, 3 = >10.

4. Discussion

The seeds of the selected species in this experiment (1995) were sowed very late (mid-July). The seeds are spring germinators (Grime, Hodgson & Hunt, 1988), so late sowing has probably an important influence on the results of the experiment. Another factor, which also can have an effect on the results, is the fact that the site was very dry. The summer in which the experiment was carried out (1995) was an extremely dry summer, with barely no rainfall. Maybe these factors are part of the explanation of the fact that the seeds of *Carex hostiana* did not germinate at all. In the end of the season they still seemed to be viable, no rotting took place. The seeds were probably turned into a deeper dormancy after they were sown, because of the 'wrong conditions' for germination in the micro-plots. Dormancy is a delaying mechanism which prevents germination under conditions which might prove to be unsuitable for establishment ('wrong conditions'). As long as the seed remains viable the possibility exists that it may eventually find itself a more favourably place (Fenner, 1985). To examine if this is the case the seeds should be stratified by a temperature of 4°C in the dark for a few weeks and tested on germination again. Another interesting thing to do is to follow the development of the sowed seeds of *Carex hostiana* in the experimental plots the following year(s).

The seeds of the other three species did germinate. In the end of the season the survived seedlings of all three sown (and germinated) species are mainly found in the outer circles (position 2 and 3) of the micro-plots. This is probably caused by the fact that in this position the seedlings are more shaded and protected by the surrounding vegetation.
The scoring of the germination and survival was very difficult, especially in the undisturbed plots with a high canopy. This fact might have influenced (lowered!) the final germination and survival percentages. The survival of the seeds was probably also (negatively) influenced by damage of snails and slugs (generalist herbivores). Although the spreading of the Doff-slugoids, these herbivores were able to eat the seedlings (or parts of them).

Statistical analysis over all species showed that there is a significant difference in germination between the disturbed and undisturbed plots: the germination in the disturbed plots was, for the tested species, significantly higher than in the undisturbed plots. These results follow the results of Altena (1983 from Bakker, 1989). He carried out sowing experiments in grasslands under restoration management. His results show that emergence was always higher in gaps than in a closed sward.In 1994 Isselstein also showed that most species germinate better on bare soil than within the existing vegetation. Soil disturbance markedly enhanced germination and emergence in all species (Isselstein, 1994). This was probably due to a better seed-soil contact when the surface had been disturbed. Isselstein also showed that *Molinea caerulea* and *Succisa pratensis* were especially susceptible to competition and hardly any seedling survived within the existing sward.

Irrigation influences the germination significantly. The seeds sowed onto the irrigated plots always had a higher average germination than those sown onto the non-irrigated plots. These result are probably also influenced by the extreme drought in the summer of 1995. However, there seems to be no difference in relative humidity between the different treated plots (Tiny-talk data). The results from the TDR measurements did show significant differences in soil moisture content between the irrigated and non-irrigated plots. The irrigated plots had a higher soil moisture content than the non-irrigated plots. This could be expected, although the amount of water the irrigated plots received differed between the different situated plots. The plots situated in replicate 3 received more then ten times the amount the irrigated plots in replicate 2 received! But from the results can be concluded that the soil beneath the irrigated plots is not saturated because the percentages are only around 30-40 %. This can also have influenced the germination and survival percentages of the seeds/seedlings.

The results discussed above follow hypothesis 3.

The results of the survival percentages could not be statistically analyzed, because of the low number of data. In 1994 de Jong did an experiment in which she also studied the germination and establishment of sowed seeds. She sowed seeds on much more different sites and used also more replicates, which gives, of course, better and more reliable results. She concluded that the light which reaches the seeds/ seedlings and disturbance of the soil are very important factors influencing germination and establishment.
In the end of the season most of the survived seedlings were situated on the irrigated (un)disturbed micro-plots, with exception of *Cirsium dissectum* which appeared on both irrigated and non-irrigated micro-plots. For the performance of these survived seedlings the expectation is that in the irrigated, disturbed micro-plots the performance of the seedlings is higher when compared to the non-irrigated undisturbed micro-plots. In these irrigated and disturbed plots the seedlings receive more water and more light, so they are able to develop better and can produce more and bigger leaves, which gives a higher performance-index. In this experiment all seedlings with the highest plant performance are indeed situated in the irrigated and disturbed micro-plots.

After analysis over all species the conclusion is that the germination is influenced by the different canopy-heights. But when the species are analyzed separately only the germination of *Cirsium dissectum* was significantly influenced by the different canopy-heights. This was probably caused by the low amount of replicates per plot. The highest germination occurred on the plots with the lowest vegetation. Assuming that the seeds need light (quantity and quality) for germination, this can be caused by the differences in photosynthetic active radiation and red/ far red ratio at the base of the canopy between the plots with different heights.

The light which passes through the vegetation is altered by the process of absorption, reflection and scattering (Smith, 1982). The amount of light reaching the seeds/

seedlings at the base of the canopy depends on the nature, structure, density and height of the vegetation. An interesting thing is to determine the relation between the height and the density or structure of a vegetation at this experimental site. In this experiment only the height of the canopy was measured. The results show that the light quantity is lower in the plots with a high canopy height. These results follow hypothesis 1.

Salisbury and Ross concluded in 1978 that the ratio of red to far red radiation is markedly reduced beneath a natural canopy. The red wavelengths are removed by leaves through photosynthesis and reflectance, but more of the far red passes through to the seeds below. The results from this experiment follows this conclusion. The red/ far red ratio (light quality) at the base of the canopy is lower in plots with a high vegetation compared to plots with a low vegetation. The higher the vegetation the less red light reaches the seeds/ seedlings. These results follow hypothesis 2.

An important factor influencing the light measurements was the litter layer at ground level. The light sensor was a fibre optic cable which was put under the canopy at the base of the canopy. During the cutting the litter was removed as far as possible, but due to the frequent cutting a litter layer had been build up. This could be an explanation for the fact that in the end of the season the differences in light quantity attenuation and red/ far red ratio between the plots with different heights became less.

As already recommended before it can be very interesting to follow the survival and plant performance and maybe the germination of the remaining seeds the coming season(s). Another interesting thing for (possible) following research is to sow more seeds of these species in different grasslands (natural, semi-natural, de-intensified) and to compare the germination and survival between these different grasslands (de Jong, 1994).

5. Conclusion

The results from this experiment confirm the hypotheses:

A higher canopy indeed attenuates more light, in terms of Photosynthetic Active Radiation (PAR). The higher the canopy, the lower the light quantity at the base of the canopy, the lower the germination. No conclusions can be drawn about survival, because the limited set of data available.

The quality of light, in terms of the red/ far red ratio, reaching the base of the canopy is indeed lower in the plots with a higher vegetation.

Irrigation and disturbance both have a positive effect on the germination of the seeds/seedlings. The disturbed plots have a higher light quality and quantity compared to the undisturbed plots. The irrigated plots have a lower light quality than the non-irrigated plots.

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Appendix

A. Data germination and Survival.

B. Data light quality and quantity. (Averages and standard deviation per date).

C. Soil water content (TDR).

D. Plant performance and position from the survived seedlings.

Used abbreviations:

Plot nr - Plot number
Dis/Undis - Disturbed/Undisturbed
Wet/Dry - irrigated/non-irrigated
N- Number of measurements per treatment
SD - Standard Deviation
Leaf - Number of leafs
Length - Length of the longest leaf
Breadth - Width of the longest leaf: Not measured in *Molinea caerulea*
Position - Position of the seedling; 1=centre, 2=inner and 3=outer circle
Germinated - All seedlings that have germinated
Not survived - The seedlings which did not survive
Survived - The seedlings that survived in the end of the season
No reading - No TDR measurement was
0 - non-irrigated and/or undisturbed
1 - irrigated and/or disturbed
Vol% - Volumetric water content

Species:
Circium - *Cirsium dissectum*
Molinea - *Molinea caerulea*
Carexhos - *Carex hostiana*
Succisa - *Succisa pratensis*

Treatments:
1-5 - Non-irrigated/Disturbed
6-10 - Non-irrigated/Undisturbed
11-15 - Irrigated/Disturbed
16-20 - Irrigated/Undisturbed

Appendix A: Germination and Survival							
Plotnr.	Species	Treatment	Water	Dis/Undis	Height(cm)	Germination	Survival
1	Cirsium	1	no water	disturbed	3	0	0
1	Molinea	1	no water	disturbed	3	0	0
1	Carexhos	1	no water	disturbed	3	0	0
1	Succisa	1	no water	disturbed	3	0	0
2	Cirsium	15	water	disturbed	30	1	0
2	Molinea	15	water	disturbed	30	2	0
2	Carexhos	15	water	disturbed	30	0	0
2	Succisa	15	water	disturbed	30	3	1
3	Cirsium	2	no water	disturbed	7	0	0
3	Molinea	2	no water	disturbed	7	0	0
3	Carexhos	2	no water	disturbed	7	0	0
3	Succisa	2	no water	disturbed	7	0	0
4	Cirsium	4	no water	disturbed	22	0	0
4	Molinea	4	no water	disturbed	22	0	0
4	Carexhos	4	no water	disturbed	22	0	0
4	Succisa	4	no water	disturbed	22	1	0
5	Cirsium	19	water	undisturbed	22	0	0
5	Molinea	19	water	undisturbed	22	0	0
5	Carexhos	19	water	undisturbed	22	0	0
5	Succisa	19	water	undisturbed	22	0	0
6	Cirsium	14	water	disturbed	22	5	2
6	Molinea	14	water	disturbed	22	0	0
6	Carexhos	14	water	disturbed	22	0	0
6	Succisa	14	water	disturbed	22	3	2
7	Cirsium	10	no water	undisturbed	30	0	0
7	Molinea	10	no water	undisturbed	30	0	0
7	Carexhos	10	no water	undisturbed	30	0	0
7	Succisa	10	no water	undisturbed	30	0	0
8	Cirsium	13	water	disturbed	15	5	4
8	Molinea	13	water	disturbed	15	3	1
8	Carexhos	13	water	disturbed	15	0	0
8	Succisa	13	water	disturbed	15	5	4
9	Cirsium	7	no water	undisturbed	7	1	1
9	Molinea	7	no water	undisturbed	7	0	0
9	Carexhos	7	no water	undisturbed	7	0	0
9	Succisa	7	no water	undisturbed	7	0	0
10	Cirsium	3	no water	disturbed	15	3	3
10	Molinea	3	no water	disturbed	15	0	0
10	Carexhos	3	no water	disturbed	15	0	0
10	Succisa	3	no water	disturbed	15	0	0
11	Cirsium	18	water	undisturbed	15	0	0
11	Molinea	18	water	undisturbed	15	0	0
11	Carexhos	18	water	undisturbed	15	0	0
11	Succisa	18	water	undisturbed	15	0	0
12	Cirsium	11	water	disturbed	3	9	6
12	Molinea	11	water	disturbed	3	3	3
12	Carexhos	11	water	disturbed	3	0	0
12	Succisa	11	water	disturbed	3	4	3
13	Cirsium	12	water	disturbed	7	2	0
13	Molinea	12	water	disturbed	7	0	0
13	Carexhos	12	water	disturbed	7	0	0
13	Succisa	12	water	disturbed	7	4	3
14	Cirsium	9	no water	undisturbed	22	0	0
14	Molinea	9	no water	undisturbed	22	0	0
14	Carexhos	9	no water	undisturbed	22	0	0
14	Succisa	9	no water	undisturbed	22	0	0
15	Cirsium	17	water	undisturbed	7	4	1
15	Molinea	17	water	undisturbed	7	0	0
15	Carexhos	17	water	undisturbed	7	0	0
15	Succisa	17	water	undisturbed	7	3	1
16	Cirsium	20	water	undisturbed	30	0	0
16	Molinea	20	water	undisturbed	30	0	0
16	Carexhos	20	water	undisturbed	30	0	0
16	Succisa	20	water	undisturbed	30	0	0
17	Cirsium	5	no water	disturbed	30	0	0

Appendix A: Germination and Survival

Plotnr.	Species	Treatment	Water	Dis/Undis	Height(cm)	Germination	Survival
17	Molinea	5	no water	disturbed	30	0	0
17	Carexhos	5	no water	disturbed	30	0	0
17	Succisa	5	no water	disturbed	30	0	0
18	Cirsium	6	no water	undisturbed	3	0	0
18	Molinea	6	no water	undisturbed	3	0	0
18	Carexhos	6	no water	undisturbed	3	0	0
18	Succisa	6	no water	undisturbed	3	0	0
19	Cirsium	8	no water	undisturbed	15	3	0
19	Molinea	8	no water	undisturbed	15	0	0
19	Carexhos	8	no water	undisturbed	15	0	0
19	Succisa	8	no water	undisturbed	15	0	0
20	Cirsium	16	water	undisturbed	3	7	3
20	Molinea	16	water	undisturbed	3	1	1
20	Carexhos	16	water	undisturbed	3	0	0
20	Succisa	16	water	undisturbed	3	1	1
21	Cirsium	3	no water	disturbed	15	0	0
21	Molinea	3	no water	disturbed	15	0	0
21	Carexhos	3	no water	disturbed	15	0	0
21	Succisa	3	no water	disturbed	15	0	0
22	Cirsium	13	water	disturbed	15	5	1
22	Molinea	13	water	disturbed	15	0	0
22	Carexhos	13	water	disturbed	15	0	0
22	Succisa	13	water	disturbed	15	1	0
23	Cirsium	16	water	undisturbed	3	11	5
23	Molinea	16	water	undisturbed	3	1	0
23	Carexhos	16	water	undisturbed	3	0	0
23	Succisa	16	water	undisturbed	3	3	3
24	Cirsium	20	water	undisturbed	30	0	0
24	Molinea	20	water	undisturbed	30	0	0
24	Carexhos	20	water	undisturbed	30	0	0
24	Succisa	20	water	undisturbed	30	0	0
25	Cirsium	14	water	disturbed	22	12	3
25	Molinea	14	water	disturbed	22	1	1
25	Carexhos	14	water	disturbed	22	0	0
25	Succisa	14	water	disturbed	22	2	1
26	Cirsium	7	no water	undisturbed	7	3	1
26	Molinea	7	no water	undisturbed	7	0	0
26	Carexhos	7	no water	undisturbed	7	0	0
26	Succisa	7	no water	undisturbed	7	0	0
27	Cirsium	10	no water	undisturbed	30	0	0
27	Molinea	10	no water	undisturbed	30	0	0
27	Carexhos	10	no water	undisturbed	30	0	0
27	Succisa	10	no water	undisturbed	30	0	0
28	Cirsium	4	no water	disturbed	22	1	1
28	Molinea	4	no water	disturbed	22	0	0
28	Carexhos	4	no water	disturbed	22	0	0
28	Succisa	4	no water	disturbed	22	0	0
29	Cirsium	18	water	undisturbed	15	10	5
29	Molinea	18	water	undisturbed	15	0	0
29	Carexhos	18	water	undisturbed	15	0	0
29	Succisa	18	water	undisturbed	15	4	3
30	Cirsium	5	no water	disturbed	30	0	0
30	Molinea	5	no water	disturbed	30	0	0
30	Carexhos	5	no water	disturbed	30	0	0
30	Succisa	5	no water	disturbed	30	0	0
31	Cirsium	17	water	undisturbed	7	1	1
31	Molinea	17	water	undisturbed	7	1	1
31	Carexhos	17	water	undisturbed	7	0	0
31	Succisa	17	water	undisturbed	7	0	0
32	Cirsium	19	water	undisturbed	22	4	4
32	Molinea	19	water	undisturbed	22	0	0
32	Carexhos	19	water	undisturbed	22	0	0
32	Succisa	19	water	undisturbed	22	0	0
33	Cirsium	1	no water	disturbed	3	13	11
33	Molinea	1	no water	disturbed	3	1	1

Appendix A: Germination and Survival							
Plotnr.	Species	Treatment	Water	Dis/Undis	Height(cm)	Germination	Survival
33	Carexhos	1	no water	disturbed	3	0	0
33	Succisa	1	no water	disturbed	3	0	0
34	Cirsium	11	water	disturbed	3	9	0
34	Molinea	11	water	disturbed	3	4	4
34	Carexhos	11	water	disturbed	3	0	0
34	Succisa	11	water	disturbed	3	2	2
35	Cirsium	9	no water	undisturbed	22	3	3
35	Molinea	9	no water	undisturbed	22	0	0
35	Carexhos	9	no water	undisturbed	22	0	0
35	Succisa	9	no water	undisturbed	22	0	0
36	Cirsium	12	water	disturbed	7	5	0
36	Molinea	12	water	disturbed	7	1	1
36	Carexhos	12	water	disturbed	7	0	0
36	Succisa	12	water	disturbed	7	0	0
37	Cirsium	8	no water	undisturbed	15	0	0
37	Molinea	8	no water	undisturbed	15	0	0
37	Carexhos	8	no water	undisturbed	15	0	0
37	Succisa	8	no water	undisturbed	15	0	0
38	Cirsium	6	no water	undisturbed	3	0	0
38	Molinea	6	no water	undisturbed	3	0	0
38	Carexhos	6	no water	undisturbed	3	0	0
38	Succisa	6	no water	undisturbed	3	0	0
39	Cirsium	15	water	disturbed	30	2	0
39	Molinea	15	water	disturbed	30	0	0
39	Carexhos	15	water	disturbed	30	0	0
39	Succisa	15	water	disturbed	30	5	2
40	Cirsium	2	no water	disturbed	7	3	3
40	Molinea	2	no water	disturbed	7	0	0
40	Carexhos	2	no water	disturbed	7	0	0
40	Succisa	2	no water	disturbed	7	0	0
41	Cirsium	17	water	undisturbed	7	7	0
41	Molinea	17	water	undisturbed	7	1	1
41	Carexhos	17	water	undisturbed	7	0	0
41	Succisa	17	water	undisturbed	7	0	0
42	Cirsium	13	water	disturbed	15	10	2
42	Molinea	13	water	disturbed	15	5	2
42	Carexhos	13	water	disturbed	15	0	0
42	Succisa	13	water	disturbed	15	0	0
43	Cirsium	5	no water	disturbed	30	0	0
43	Molinea	5	no water	disturbed	30	0	0
43	Carexhos	5	no water	disturbed	30	0	0
43	Succisa	5	no water	disturbed	30	4	4
44	Cirsium	2	no water	disturbed	7	0	0
44	Molinea	2	no water	disturbed	7	0	0
44	Carexhos	2	no water	disturbed	7	0	0
44	Succisa	2	no water	disturbed	7	0	0
45	Cirsium	6	no water	undisturbed	3	1	0
45	Molinea	6	no water	undisturbed	3	0	0
45	Carexhos	6	no water	undisturbed	3	0	0
45	Succisa	6	no water	undisturbed	3	0	0
46	Cirsium	18	water	undisturbed	15	1	0
46	Molinea	18	water	undisturbed	15	0	0
46	Carexhos	18	water	undisturbed	15	0	0
46	Succisa	18	water	undisturbed	15	0	0
47	Cirsium	15	water	disturbed	30	1	0
47	Molinea	15	water	disturbed	30	0	0
47	Carexhos	15	water	disturbed	30	0	0
47	Succisa	15	water	disturbed	30	4	2
48	Cirsium	14	water	disturbed	22	6	2
48	Molinea	14	water	disturbed	22	13	7
48	Carexhos	14	water	disturbed	22	0	0
48	Succisa	14	water	disturbed	22	1	1
49	Cirsium	19	water	undisturbed	22	1	0
49	Molinea	19	water	undisturbed	22	0	0
49	Carexhos	19	water	undisturbed	22	0	0

Appendix A: Germination and Survival							
Plotnr.	Species	Treatment	Water	Dis/Undis	Height(cm)	Germination	Survival
49	Succisa	19	water	undisturbed	22	1	1
50	Cirsium	1	no water	disturbed	3	3	2
50	Molinea	1	no water	disturbed	3	0	0
50	Carexhos	1	no water	disturbed	3	0	0
50	Succisa	1	no water	disturbed	3	0	0
51	Cirsium	7	no water	undisturbed	7	1	1
51	Molinea	7	no water	undisturbed	7	0	0
51	Carexhos	7	no water	undisturbed	7	0	0
51	Succisa	7	no water	undisturbed	7	2	0
52	Cirsium	20	water	undisturbed	30	0	0
52	Molinea	20	water	undisturbed	30	0	0
52	Carexhos	20	water	undisturbed	30	0	0
52	Succisa	20	water	undisturbed	30	0	0
53	Cirsium	9	no water	undisturbed	22	0	0
53	Molinea	9	no water	undisturbed	22	0	0
53	Carexhos	9	no water	undisturbed	22	0	0
53	Succisa	9	no water	undisturbed	22	0	0
54	Cirsium	12	water	disturbed	7	14	8
54	Molinea	12	water	disturbed	7	7	5
54	Carexhos	12	water	disturbed	7	0	0
54	Succisa	12	water	disturbed	7	3	3
55	Cirsium	10	no water	undisturbed	30	0	0
55	Molinea	10	no water	undisturbed	30	0	0
55	Carexhos	10	no water	undisturbed	30	0	0
55	Succisa	10	no water	undisturbed	30	0	0
56	Cirsium	3	no water	disturbed	15	6	1
56	Molinea	3	no water	disturbed	15	0	0
56	Carexhos	3	no water	disturbed	15	0	0
56	Succisa	3	no water	disturbed	15	0	0
57	Cirsium	8	no water	undisturbed	15	4	3
57	Molinea	8	no water	undisturbed	15	0	0
57	Carexhos	8	no water	undisturbed	15	0	0
57	Succisa	8	no water	undisturbed	15	0	0
58	Cirsium	11	water	disturbed	3	11	5
58	Molinea	11	water	disturbed	3	5	4
58	Carexhos	11	water	disturbed	3	0	0
58	Succisa	11	water	disturbed	3	1	1
59	Cirsium	4	no water	disturbed	22	7	4
59	Molinea	4	no water	disturbed	22	0	0
59	Carexhos	4	no water	disturbed	22	0	0
59	Succisa	4	no water	disturbed	22	0	0
60	Cirsium	16	water	undisturbed	3	8	3
60	Molinea	16	water	undisturbed	3	3	3
60	Carexhos	16	water	undisturbed	3	0	0
60	Succisa	16	water	undisturbed	3	4	1

Appendix B: Light Quality and Quantity

Quality (PAR)

Date	Treatment	Plot nr	N	Average	SD	Attenuation
19/6/95	1	1,33,50	30	0.858952	0.130292	14.1048
19/6/95	2	3,40,44	30	0.565411	0.227908	43.4589
19/6/95	3	10,21,56	30	0.436053	0.181369	56.3947
19/6/95	4	4,28,59	30	0.161896	0.107251	83.8104
19/6/95	5	17,30,49	30	0.022341	0.028574	97.7659
19/6/95	6	18,38,45	30	0.345745	0.23221	65.4255
19/6/95	7	9,26,51	30	0.196497	0.110597	80.3503
19/6/95	8	19,37,57	30	0.181704	0.174812	81.8296
19/6/95	9	14,35,53	30	0.020878	0.031498	97.9122
19/6/95	10	7,27,55	30	0.010477	0.026358	98.9523
19/6/95	11	12,34,58	30	0.886471	0.094212	11.3529
19/6/95	12	13,36,54	30	0.754004	0.123708	24.5996
19/6/95	13	8,22,42	30	0.533289	0.260384	46.6711
19/6/95	14	6,25,48	30	0.194972	0.130894	80.5028
19/6/95	15	2,39,47	30	0.085447	0.104057	91.4553
19/6/95	16	20,23,60	30	0.284147	0.186777	71.5853
19/6/95	17	15,31,41	30	0.21687	0.166246	78.313
19/6/95	18	11,29,46	30	0.140337	0.17352	85.9663
19/6/95	19	5,32,43	30	0.028766	0.044196	97.1234
19/6/95	20	16,24,52	30	0.006001	0.012579	99.3999
27/6/95	1	1,33,50	30	0.859711	0.125323	14.0289
27/6/95	2	3,40,44	30	0.363862	0.250899	63.6138
27/6/95	3	10,21,56	30	0.253567	0.197603	74.6433
27/6/95	4	4,28,59	30	0.019854	0.00118	98.0146
27/6/95	5	17,30,49	30	0.007904	0.025072	99.2096
27/6/95	6	18,38,45	30	0.507042	0.501759	49.2958
27/6/95	7	9,26,51	30	0.274521	0.263783	72.5479
27/6/95	8	19,37,57	30	0.120997	0.39585	87.9003
27/6/95	9	14,35,53	30	0.000365	0.00139	99.9635
27/6/95	10	7,27,55	30	0.00943	0.021698	99.057
27/6/95	11	12,34,58	30	0.694613	0.277623	30.5387
27/6/95	12	13,36,54	30	0.379109	0.283863	62.0891
27/6/95	13	8,22,42	30	0.214481	0.161208	78.5519
27/6/95	14	6,25,48	30	0.138486	0.075677	86.1514
27/6/95	15	2,39,47	30	0.016292	0.008082	98.3708
27/6/95	16	20,23,60	30	0.311531	0.177297	68.8469
27/6/95	17	15,31,41	30	0.207593	0.293607	79.2407
27/6/95	18	11,29,46	30	0.021504	0.036142	97.8496
27/6/95	19	5,32,43	30	0.024997	0.054792	97.5003
27/6/95	20	16,24,52	30	0.000424	0.001393	99.9576
1/8/95	1	1,33,50	30	0.679618	0.297147	32.0382
1/8/95	2	3,40,44	30	0.563511	0.292318	43.6489
1/8/95	3	10,21,56	30	0.418691	0.244624	58.1309
1/8/95	4	4,28,59	30	0.13938	0.064017	86.062
1/8/95	5	17,30,49	30	0.006198	0.013075	99.3802
1/8/95	6	18,38,45	30	0.542723	0.291543	45.7277
1/8/95	7	9,26,51	30	0.341579	0.194419	65.8421
1/8/95	8	19,37,57	30	0.161048	0.1146	83.8952
1/8/95	9	14,35,53	30	0.059182	0.045666	94.0818
1/8/95	10	7,27,55	30	0.004273	0.008331	99.5727
1/8/95	11	12,34,58	30	0.732548	0.22499	26.7452

Appendix B: Light Quality and Quantity

Quality (PAR)

Date	Treatment	Plot nr	N	Average	SD	Attenuation
1/8/95	12	13,36,54	30	0.589886	0.256833	41.0114
1/8/95	13	8,22,42	30	0.462225	0.314985	53.7775
1/8/95	14	6,25,48	30	0.179458	0.092358	82.0542
1/8/95	15	2,39,47	30	0.004997	0.012337	99.5003
1/8/95	16	20,23,60	30	0.532973	0.238134	46.7027
1/8/95	17	15,31,41	30	0.240026	0.225308	75.9974
1/8/95	18	11,29,46	30	0.168065	0.142216	83.1935
1/8/95	19	5,32,43	30	0.086533	0.146432	91.3467
1/8/95	20	16,24,52	30	0.00168	0.003366	99.832
9/8/95	1	1,33	20	0.476732	0.328524	52.3268
9/8/95	2	3,40	20	0.356094	0.253616	64.3906
9/8/95	3	10,21	20	0.284582	0.164374	71.5418
9/8/95	4	4,28	20	0.047423	0.043893	95.2577
9/8/95	5	17,30	20	0.003838	0.012602	99.6162
9/8/95	6	18,38	20	0.321515	0.241183	67.8485
9/8/95	7	9,26	20	0.260241	0.17894	73.9759
9/8/95	8	19,37	20	0.085871	0.105401	91.4129
9/8/95	9	14,35	20	0.039691	0.0486	96.0309
9/8/95	10	7,27	20	0.005427	0.009116	99.4573
9/8/95	11	12,34	20	0.381108	0.266841	61.8892
9/8/95	12	13,36	20	0.406803	0.276824	59.3197
9/8/95	13	8,22	20	0.090356	0.101701	90.9644
9/8/95	14	6,25	20	0.209918	0.226295	79.0082
9/8/95	15	2,39	20	0.008874	0.018441	99.1126
9/8/95	16	20,23	20	0.160365	0.189485	83.9635
9/8/95	17	15,31	20	0.241135	0.211935	75.8865
9/8/95	18	11,29	20	0.053711	0.049944	94.6289
9/8/95	19	5,32	20	0.065862	0.046879	93.4138
9/8/95	20	16,24	20	0.000345	0.001542	99.9655
16/8/95	1	1,33	20	0.624834	0.258356	37.51658
16/8/95	2	3,40	20	0.624235	0.346076	37.57645
16/8/95	3	10,21	20	0.115108	0.056854	88.48915
16/8/95	4	4,28	20	0.072746	0.049696	92.72542
16/8/95	5	17,30	20	0.002862	0.005174	99.71376
16/8/95	6	18,38	20	0.488797	0.25925	51.1203
16/8/95	7	9,26	20	0.33986	0.28685	66.01404
16/8/95	8	19,37	20	0.009819	0.012715	99.01807
16/8/95	9	14,35	20	0.009993	0.012564	99.00074
16/8/95	10	7,27	20	0.003957	0.007388	99.6043
16/8/95	11	12,34	20	0.550509	0.27641	44.94906
16/8/95	12	13,36	20	0.547726	0.287068	45.22739
16/8/95	13	8,22	20	0.119717	0.094466	88.02828
16/8/95	14	6,25	20	0.123485	0.119411	87.65155
16/8/95	15	2,39	20	0.012447	0.030258	98.75528
16/8/95	16	20,23	20	0.412693	0.260786	58.73068
16/8/95	17	15,31	20	0.236495	0.314344	76.35055
16/8/95	18	11,29	20	0.008191	0.012785	99.18089
16/8/95	19	5,32	20	0.01654	0.018613	98.34601
16/8/95	20	16,24	20	0.000276	0.001235	99.97238
25/8/95	1	1,33	20	0.346474	0.347374	65.35264
25/8/95	2	3,40	20	0.249992	0.184848	75.00076

Appendix B: Light Quality and Quantity

Quality (PAR)

Date	Treatment	Plot nr	N	Average	SD	Attenuation
25/8/95	3	10,21	20	0.291992	0.208748	70.80078
25/8/95	4	4,28	20	0.187673	0.164084	81.2327
25/8/95	5	17,30	20	0.005061	0.114474	99.49394
25/8/95	6	18,38	20	0.205814	0.25315	79.41856
25/8/95	7	9,26	20	0.17174	0.202895	82.82599
25/8/95	8	19,37	20	0.10091	0.157169	89.90898
25/8/95	9	14,35	20	0.01504	0.075366	98.496
25/8/95	10	7,27	20	0.003401	0.016301	99.6599
25/8/95	11	12,34	20	0.356203	0.341106	64.37971
25/8/95	12	13,36	20	0.31921	0.141485	68.079
25/8/95	13	8,22	20	0.244414	0.111065	75.5586
25/8/95	14	6,25	20	0.171505	0.171833	82.84949
25/8/95	15	2,39	20	0.010178	0.175147	98.98218
25/8/95	16	20,23	20	0.138097	0.214297	86.19026
25/8/95	17	15,31	20	0.149432	0.246433	85.05677
25/8/95	18	11,29	20	0.046816	0.218981	95.31845
25/8/95	19	5,32	20	0.033218	0.149144	96.67816
25/8/95	20	16,24	20	0.000575	0.038461	99.94253
31/8/95	1	1,33	20	0.431162	0.387443	56.8838
31/8/95	2	3,40	20	0.236555	0.220693	76.34446
31/8/95	3	10,21	20	0.262434	0.162857	73.75663
31/8/95	4	4,28	20	0.099397	0.13695	90.06026
31/8/95	5	17,30	20	0.005581	0.068247	99.44189
31/8/95	6	18,38	20	0.227513	0.279036	77.24873
31/8/95	7	9,26	20	0.200353	0.234476	79.96472
31/8/95	8	19,37	20	0.090581	0.204969	90.94192
31/8/95	9	14,35	20	0.005927	0.018014	99.40728
31/8/95	10	7,27	20	0.001363	0.009707	99.86372
31/8/95	11	12,34	20	0.361469	0.34689	63.85306
31/8/95	12	13,36	20	0.28419	0.161229	71.58098
31/8/95	13	8,22	20	0.244133	0.105104	75.58665
31/8/95	14	6,25	20	0.301934	0.192175	69.80659
31/8/95	15	2,39	20	0.034303	0.277536	96.56966
31/8/95	16	20,23	20	0.177993	0.232596	82.20067
31/8/95	17	15,31	20	0.09384	0.212087	90.61602
31/8/95	18	11,29	20	0.009512	0.148637	99.04883
31/8/95	19	5,32	20	0.007112	0.010294	99.28883
31/8/95	20	16,24	20	0.000383	0.008402	99.96169

Appendix B: Light Quality and Quantity

Quantity (Red/FarRed)

Date	Treatment	Plot nr	N	Average	SD	Ratio
19/6/95	1	1,33,50	30	0.914796	0.044773	8.520428
19/6/95	2	3,40,44	30	0.777074	0.23725	22.29264
19/6/95	3	10,21,56	30	0.892856	0.146878	10.71444
19/6/95	4	4,28,59	30	0.748242	0.090692	25.17577
19/6/95	5	17,30,49	30	0.423826	0.132345	57.61736
19/6/95	6	18,38,45	30	0.725646	0.24025	27.43543
19/6/95	7	9,26,51	30	0.678161	0.187157	32.18391
19/6/95	8	19,37,57	30	0.596856	0.239018	40.31442
19/6/95	9	14,35,53	30	0.405537	0.111719	59.44632
19/6/95	10	7,27,55	30	0.289367	0.208015	71.06328
19/6/95	11	12,34,58	30	0.964638	0.028358	3.536196
19/6/95	12	13,36,54	30	0.952488	0.032013	4.751201
19/6/95	13	8,22,42	30	0.743931	0.222722	25.60691
19/6/95	14	6,25,48	30	0.629431	0.201477	37.05693
19/6/95	15	2,39,47	30	0.562843	0.138941	43.71575
19/6/95	16	20,23,60	30	0.729997	0.205428	27.00033
19/6/95	17	15,31,41	30	0.593176	0.152196	40.68238
19/6/95	18	11,29,46	30	0.596068	0.15973	40.39315
19/6/95	19	5,32,43	30	0.33975	0.139154	66.02496
19/6/95	20	16,24,52	30	0.180018	0.182228	81.99817
27/6/95	1	1,33,50	30	0.81188	0.074523	18.81204
27/6/95	2	3,40,44	30	0.915927	0.042035	8.40733
27/6/95	3	10,21,56	30	0.761949	0.033499	23.80513
27/6/95	4	4,28,59	30	0.270027	0.073914	72.9973
27/6/95	5	17,30,49	30	0.190475	0.0167	80.95248
27/6/95	6	18,38,45	30	0.462478	0.009613	53.75217
27/6/95	7	9,26,51	30	0.930836	0.039487	6.91635
27/6/95	8	19,37,57	30	0.604581	0.095521	39.54194
27/6/95	9	14,35,53	30	0.40282	0.039126	59.71799
27/6/95	10	7,27,55	30	0.35248	0.083092	64.75199
27/6/95	11	12,34,58	30	0.896907	0.028071	10.30928
27/6/95	12	13,36,54	30	0.92672	0.010051	7.327967
27/6/95	13	8,22,42	30	0.704255	0.224289	29.57454
27/6/95	14	6,25,48	30	0.533972	0.055913	46.6028
27/6/95	15	2,39,47	30	0.412311	0.180914	58.76888
27/6/95	16	20,23,60	30	0.323288	0.019031	67.67116
27/6/95	17	15,31,41	30	0.434285	0.034279	56.57155
27/6/95	18	11,29,46	30	0.439923	0.046317	56.00771
27/6/95	19	5,32,43	30	0.390066	0.065159	60.99338
27/6/95	20	16,24,52	30	0.344524	0.008448	65.54755
1/8/95	1	1,33,50	30	0.86117	0.09699	13.88299
1/8/95	2	3,40,44	30	0.644494	0.188686	35.55057
1/8/95	3	10,21,56	30	0.658265	0.15971	34.17346
1/8/95	4	4,28,59	30	0.607519	0.135384	39.24814
1/8/95	5	17,30,49	30	0.477115	0.128885	52.28854
1/8/95	6	18,38,45	30	0.486826	0.184353	51.31744
1/8/95	7	9,26,51	30	0.589663	0.702532	41.03366
1/8/95	8	19,37,57	30	0.443651	0.154981	55.6349
1/8/95	9	14,35,53	30	0.559539	0.099361	44.04609
1/8/95	10	7,27,55	30	0.224806	0.178819	77.51943
1/8/95	11	12,34,58	30	0.864751	0.067443	13.52491

Appendix B: Light Quality and Quantity

Quantity (Red/FarRed)

Date	Treatment	Plot nr	N	Average	SD	Ratio
1/8/95	12	13,36,54	30	0.71323	0.190911	28.67702
1/8/95	13	8,22,42	30	0.531751	0.13639	46.82489
1/8/95	14	6,25,48	30	0.66986	0.092319	33.01402
1/8/95	15	2,39,47	30	0.272934	0.155728	72.70658
1/8/95	16	20,23,60	30	0.477961	0.156503	52.2039
1/8/95	17	15,31,41	30	0.232022	0.137583	76.79782
1/8/95	18	11,29,46	30	0.366967	0.114385	63.30328
1/8/95	19	5,32,43	30	0.392729	0.173744	60.72712
1/8/95	20	16,24,52	30	0.187186	0.179477	81.28138
9/8/95	1	1,33	20	0.464332	0.135616	53.56682
9/8/95	2	3,40	20	0.450915	0.159015	54.9085
9/8/95	3	10,21	20	0.423457	0.095892	57.65433
9/8/95	4	4,28	20	0.444547	0.094981	55.5453
9/8/95	5	17,30	20	0.393165	0.064636	60.68351
9/8/95	6	18,38	20	0.344306	0.209104	65.56937
9/8/95	7	9,26	20	0.404611	0.097581	59.53886
9/8/95	8	19,37	20	0.388985	0.111415	61.10154
9/8/95	9	14,35	20	0.338955	0.050258	66.10449
9/8/95	10	7,27	20	0.346772	0.179775	65.32279
9/8/95	11	12,34	20	0.27368	0.124899	72.63196
9/8/95	12	13,36	20	0.260765	0.110775	73.92354
9/8/95	13	8,22	20	0.30734	0.069347	69.26595
9/8/95	14	6,25	20	0.34429	0.054381	65.57098
9/8/95	15	2,39	20	0.271718	0.039091	72.82822
9/8/95	16	20,23	20	0.363506	0.239305	63.64941
9/8/95	17	15,31	20	0.363272	0.095372	63.67276
9/8/95	18	11,29	20	0.334816	0.122491	66.51844
9/8/95	19	5,32	20	0.306458	0.105016	69.35415
9/8/95	20	16,24	20	0.142999	0.098198	85.70006
16/8/95	1	1,33	20	0.433004	0.190604	56.69965
16/8/95	2	3,40	20	0.635935	0.089235	36.40647
16/8/95	3	10,21	20	0.632207	0.077717	36.77925
16/8/95	4	4,28	20	0.608799	0.141655	39.12014
16/8/95	5	17,30	20	0.573142	0.099701	42.68581
16/8/95	6	18,38	20	0.275228	0.087475	72.47723
16/8/95	7	9,26	20	0.350424	0.147738	64.95763
16/8/95	8	19,37	20	0.20224	0.070609	79.77601
16/8/95	9	14,35	20	0.462027	0.091563	53.79733
16/8/95	10	7,27	20	0.417753	0.251284	58.2247
16/8/95	11	12,34	20	0.673984	0.125668	32.60156
16/8/95	12	13,36	20	0.64369	0.079292	35.63099
16/8/95	13	8,22	20	0.4662	0.052102	53.37996
16/8/95	14	6,25	20	0.588574	0.084742	41.14261
16/8/95	15	2,39	20	0.28411	0.122854	71.58905
16/8/95	16	20,23	20	0.315881	0.095256	68.41191
16/8/95	17	15,31	20	0.241712	0.130858	75.82882
16/8/95	18	11,29	20	0.30731	0.085341	69.26898
16/8/95	19	5,32	20	0.239914	0.072753	76.00865
16/8/95	20	16,24	20	0.187186	0.170137	81.28139
25/8/95	1	1,33	20	0.853997	0.056174	14.60026
25/8/95	2	3,40	20	0.924941	0.02405	7.505922

Appendix B: Light Quality and Quantity

Quantity (Red/FarRed)

Date	Treatment	Plot nr	N	Average	SD	Ratio
25/8/95	3	10,21	20	0.943136	0.043833	5.686401
25/8/95	4	4,28	20	0.853873	0.029838	14.6127
25/8/95	5	17,30	20	0.707971	0.252182	29.2029
25/8/95	6	18,38	20	0.616709	0.071314	38.32905
25/8/95	7	9,26	20	0.653819	0.120947	34.61814
25/8/95	8	19,37	20	0.630685	0.060955	36.93147
25/8/95	9	14,35	20	0.510794	0.138561	48.92056
25/8/95	10	7,27	20	0.441111	0.237703	55.88889
25/8/95	11	12,34	20	0.918655	0.16983	8.134493
25/8/95	12	13,36	20	0.885932	0.038327	11.40679
25/8/95	13	8,22	20	0.874275	0.053218	12.57252
25/8/95	14	6,25	20	0.879966	0.055767	12.00341
25/8/95	15	2,39	20	0.769778	0.063454	23.02216
25/8/95	16	20,23	20	0.64838	0.092592	35.16204
25/8/95	17	15,31	20	0.441012	0.059116	55.89875
25/8/95	18	11,29	20	0.303373	0.203973	69.6627
25/8/95	19	5,32	20	0.776327	0.101324	22.36729
25/8/95	20	16,24	20	0.282825	0.142203	71.71746
31/8/95	1	1,33	20	0.523721	0.039642	47.62795
31/8/95	2	3,40	20	0.718791	0.05023	28.12085
31/8/95	3	10,21	20	0.625351	0.041791	37.46493
31/8/95	4	4,28	20	0.721977	0.015993	27.80233
31/8/95	5	17,30	20	0.713735	0.119383	28.62648
31/8/95	6	18,38	20	0.400433	0.07734	59.95667
31/8/95	7	9,26	20	0.397846	0.08202	60.21543
31/8/95	8	19,37	20	0.715185	0.096071	28.48155
31/8/95	9	14,35	20	0.277441	0.175901	72.25593
31/8/95	10	7,27	20	0.46999	0.188081	53.001
31/8/95	11	12,34	20	0.524847	0.148418	47.51527
31/8/95	12	13,36	20	0.818593	0.058981	18.14075
31/8/95	13	8,22	20	0.780941	0.0694	21.90595
31/8/95	14	6,25	20	0.674053	0.10377	32.59471
31/8/95	15	2,39	20	0.565912	0.146503	43.40884
31/8/95	16	20,23	20	0.413546	0.186612	58.64535
31/8/95	17	15,31	20	0.361968	0.115705	63.80318
31/8/95	18	11,29	20	0.297749	0.112452	70.22506
31/8/95	19	5,32	20	0.580291	0.042276	41.97085
31/8/95	20	16,24	20	0.254281	0.060619	74.57191

Appendix D: Plantperformance

Plotnr	Species	Leaf	Lenght	Breadth	Position
1	no germination / survival				
2	no germination / survival				
3	no germination / survival				
4	no germination / survival				
5	no germination / survival				
6	Cirsium	4	25	12	1
	Cirsium	4	36	17	2
	Cirsium	2	9	8	3
7	no germination / survival				
8	Cirsium	4	40	16	3
	Cirsium	3	31	11	3
	Cirsium	3	39	12	3
	Molinea	3	30		2
9	Cirsium	3	26	11	3
10	no germination / survival				
11	no germination / survival				
12	Cirsium	2	9	5	3
	Cirsium	2	8	5	3
	Cirsium	2	11	6	2
	Cirsium	4	28	11	3
	Cirsium	4	27	14	3
	Cirsium	5	36	16	3
	Molinea	4	23		3
	Molinea	3	12		3
	Molinea	3	12		3
	Succisa	6	6	6	2
	Succisa	4	5	3	2
	Succisa	4	4	3	3
13	Succisa	4	5	3	3
	Succisa	4	7	4	3
	Succisa	6	8	5	3
14	no germination / survival				
15	Cirsium	2	6	3	3
	Succisa	4	6	4	2

Plotnr	Species	Leaf	Lenght	Breadth	Position
34	Cirsium	4	14	6	3
	Cirsium	3	5	4	1
	Cirsium	2	12	7	3
	Cirsium	2	11	7	3
	Cirsium	3	17	7	3
	Molinea	2	13		2
	Molinea	2	6		2
	Molinea	3	15		2
	Succisa	6	8	6	3
	Succisa	4	10	6	3
35	no germination / survival				
36	Cirsium	4	4	3	3
	Molinea	4	33		2
37	no germination / survival				
38	no germination / survival				
39	no germination / survival				
40	no germination / survival				
41	Cirsium	2	9	5	3
	Cirsium	2	10	5	3
	Succisa	4	10	4	2
42	Cirsium	3	31	10	2
	Cirsium	2	11	4	3
	Molinea	4	18		1
	Molinea	2	6		1
43	no germination / survival				
44	no germination / survival				
45	Cirsium	2	14	6	3
46	no germination / survival				
47	Succisa	2	9	5	1
48	Cirsium	2	8	4	3
	Cirsium	3	35	20	3
	Cirsium	3	14	7	3
	Molinea	3	22		1
	Molinea	4	24		2

Appendix D: Plantperformance

Plotnr	Species	Leaf	Lenght	Breadth	Position
16	no germination / survival				
17	no germination / survival				
18	no germination / survival				
19	no germination / survival				
20	Molinea	2	29		3
	Succisa	4	7	5	3
21	no germination / survival				
22	no germination / survival				
23	Cirsium	2	9	5	3
	Cirsium	4	18	7	3
	Cirsium	2	4	4	3
	Cirsium	5	19	7	3
	Succisa	3	11	7	3
	Succisa	6	7	6	3
	Succisa	5	9	5	3
	Succisa	6	7	5	3
	Succisa	4	7	4	3
	Succisa	3	7	3	3
	Succisa	6	4	3	3
24	no germination / survival				
25	Cirsium	4	17	7	1
	Cirsium	2	4	3	2
	Cirsium	2	4	3	3
	Molinea	2	10		2
26	Cisium	2	10	5	3
27	no germination / survival				
28	Cirsium	5	18	7	3
29	Cirsium	3	14	5	2
	Cirsium	3	6	4	2
	Cirsium	3	7	6	3
	Succisa	4	9	5	1
	Succisa	4	6	4	2
	Succisa	4	7	4	1
	Succisa	4	5	3	2

Plotnr	Species	Leaf	Lenght	Breadth	Position
	Molinea	5	30		2
	Molinea	5	32		1
	Molinea	3	20		2
	Molinea	6	41		2
	Molinea	5	36		2
	Molinea	5	30		1
	Molinea	4	30		3
	Succisa	6	10	6	3
49	Succisa	2	9	4	1
50	Cirsium	3	6	5	2
	Cirsium	3	9	6	2
51	no germination / survival				
52	no germination / survival				
53	no germination / survival				
54	Cirsium	2	10	6	1
	Cirsium	2	20	11	2
	Cirsium	2	22	11	2
	Cirsium	3	13	5	1
	Cirsium	3	14	7	2
	Cirsium	2	12	7	2
	Cirsium	2	10	5	2
	Molinea	4	13		2
	Molinea	4	24		2
	Molinea	3	25		2
	Molinea	3	15		2
	Molinea	4	33		1
	Succisa	4	8	6	1
	Succisa	5	7	6	3
	Succisa	5	6	5	2
55	no germination / survival				
56	Cirsium	5	20	10	2
57	Cirsium	4	10	6	3
58	Cirsium	2	13	5	2
	Cirsium	3	25	15	1

Appendix D: Plantperformance

Plotnr	Species	Leaf	Lenght	Breadth	Position		Plotnr	Species	Leaf	Lenght	Breadth	Position
30	no germination / survival							Cirsium	3	15	7	2
31	Cirsium	4	41	12	3			Cirsium	3	14	7	2
	Cirsium	2	24	7	3			Cirsium	2	18	11	3
32	no germination / survival							Molinea	2	11		1
33	Cirsium	4	4	7	1			Molinea	4	27		3
	Cirsium	3	9	7	1			Molinea	4	18		2
	Cirsium	4	9	7	1			Molinea	4	17		2
	Cirsium	2	5	4	1			Succisa	4	7	4	1
	Cirsium	3	10	6	2		59	Cirsium	2	10	5	1
	Cirsium	3	10	7	2			Cirsium	3	6	5	1
	Cirsium	2	9	5	2			Cirsium	3	11	6	1
	Cirsium	3	7	5	2			Cirsium	3	10	5	2
	Cirsium	4	9	6	2			Cirsium	3	10	5	2
	Cirsium	3	8	5	2		60	Cirsium	3	14	5	1
	Cirsium	4	7	5	2			Succisa	6	10	7	2

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