Zeitschrift: Veröffentlichungen des Geobotanischen Institutes der Eidg. Tech. Hochschule, Stiftung Rübel, in Zürich

Herausgeber: Geobotanisches Institut, Stiftung Rübel (Zürich)

Band: 104 (1990)

Artikel: Influence of gaps and neighbouring plants on seedling establishment in limestone grassland : experimental field studies in northern Switzerland = Einfluss von Kahlstellen und benachbarten Pflanzen auf die Keimlingsentwicklung in Trespen-Halbtrochenrasen : experimentelle Felduntersuchungen in der Nordschweiz

Autor: Ryser, Peter

Kapitel: 2: Study site and methods

DOI: https://doi.org/10.5169/seals-308913

2. STUDY SITE AND METHODS

2.1. SITE DESCRIPTION

The study site is located in northern Switzerland in Merishausen, 7.5 km north of Schaffhausen. It lies on the Gräte, a hill at the northeastern end of the Jurassic mountains, the Randen, at 710 m a.s.l. (47°45'50"N and 8°36'58"E, National Grid Reference 688230/290950) (Fig. 1).

The vegetation is a nutrient poor grassland of the type *Mesobrometum erecti*, subassociation with *Medicago falcata* (ZOLLER 1954a). The site was used as an arable field until about one hundred years ago. The actual management consists of a yearly mowing in Mid-July, and there is no fertilizer treatment. Natural grazing by roes (*Capreolus capreolus*) and smaller animals occurs. The dominating grass is *Bromus erectus*, other common graminoids are *Briza media, Festuca ovina, Carex caryophyllea* and *Carex flacca*. The most common dicots are *Salvia pratensis, Sanguisorba minor, Onobrychis viciifolia* and *Leucanthemum vulgare*. The meadow is species-rich, having about 40 species of vascular plants and several mosses per square meter. Species density is high even in small-scale, the mean being 11 species per 100 cm^2. The maximum standing crop is about 300 g/m^2 dry matter (measured in mid-July 1987); 90% of this above-ground biomass is below the height of 25 cm.

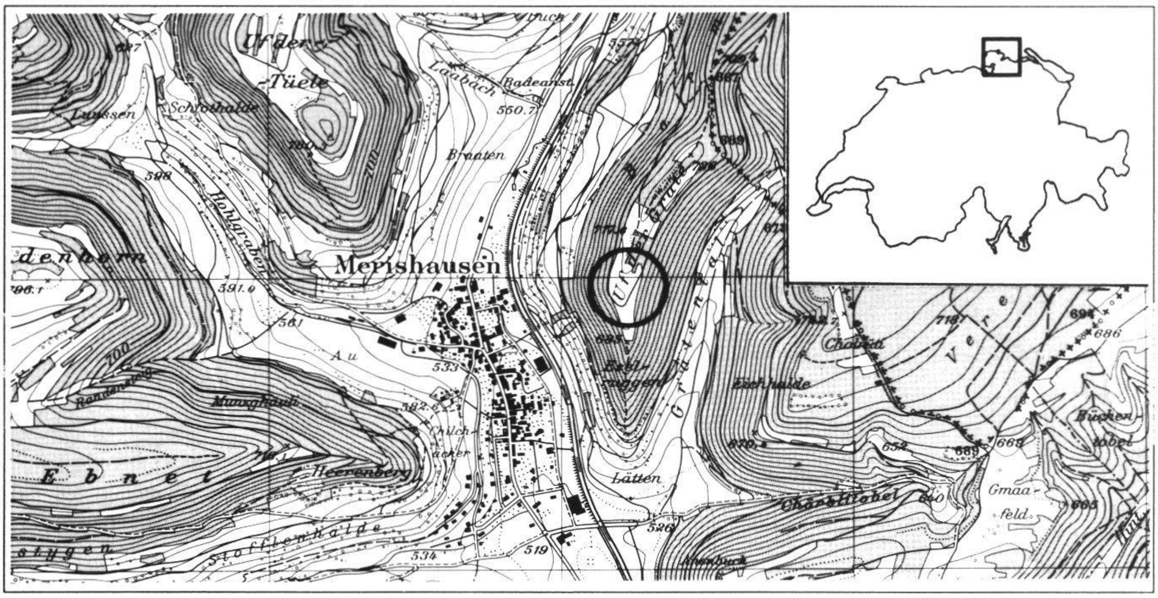

Fig. 1. Location of the study site.
Permission for copyright by the Bundesamt für Landestopographie from July 18, 1990

The soil is a nutrient poor marly rendzina on γ-marl limestone with a skeleton-free top layer of 10-15 cm. The pH ($CaCl_2$) varies between 7.1 and 7.4.

2.2. CLIMATIC CONDITIONS

All the climatic data presented here were collected by the Swiss Meteorological Institute, and also the phenological description is based on their data. The precipitation is measured in Merishausen (572 m a.s.l.) 1.5 km north of the study site. The temperature measurements were made at the weather station in Schaffhausen (437 m a.s.l.) 8 km south of the study site. Description of the snow-cover is based on data of the weather station in Hallau (435 m a.s.l.), 13 km to the south-west of the study site.

The yearly course of the long-term average monthly precipitation and mean temperature are presented in Fig. 2. The average yearly precipitation in Merishausen is 910 mm, the highest values in summer (June 100.6 mm) and lowest in late winter (February 57.8 mm). The average mean temperature of the year in Schaffhausen is 8.0°C, with maximum in July, 17.1°C, and minimum in January, -1.7°C. As the study site lies about 300 m higher than the weather station of Schaffhausen, the mean temperature there is probably 1-2°C colder.

A short summary of the climatic conditions during the study period is presented here with an emphasis on the data relevant for the interpretation of the results. The course of monthly precipitation and mean temperature can be seen in Fig. 2.

1986. The precipitation and temperature in summer were above average, so that after a late spring the year was phenologically normal from May onwards. The end of August was fairly wet, but after the sowing of the seeds on the 29th and 30th of August the autumn was very dry, with periods of 13 and 29 days without any precipitation until mid-October. The last third of October was rainy, November again dry. The mean temperatures in autumn were above long-term average. During the last third of December there was some snow.

1987. Snow covered the ground during the major part of January, the last third of February and the beginning of March. April was warm and dry with only 45 mm precipitation. After the cold, wet May and June the whole phenological development was late during the summer. Because of the rainy weather the study site could not be mown until the 13th of August. The day of mowing was followed by 4 dry days with high temperatures (max. 30.1°C).

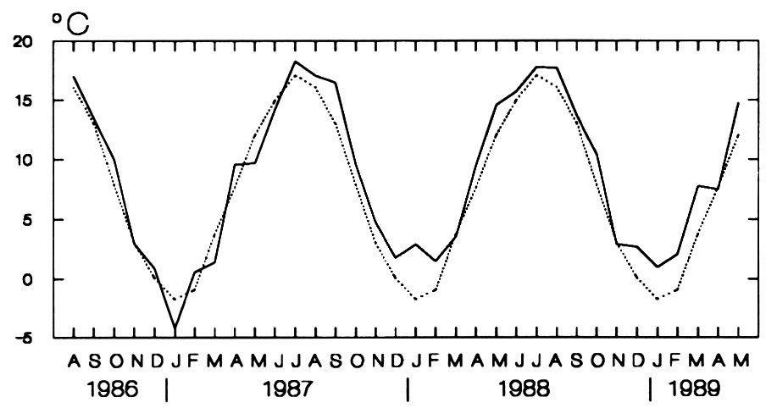

Fig. 2a. Mean monthly temperature in Schaffhausen, 437 m a.s.l.

.... Average of 1901 to 1960
——— Values for the study period August 1986 to May 1989

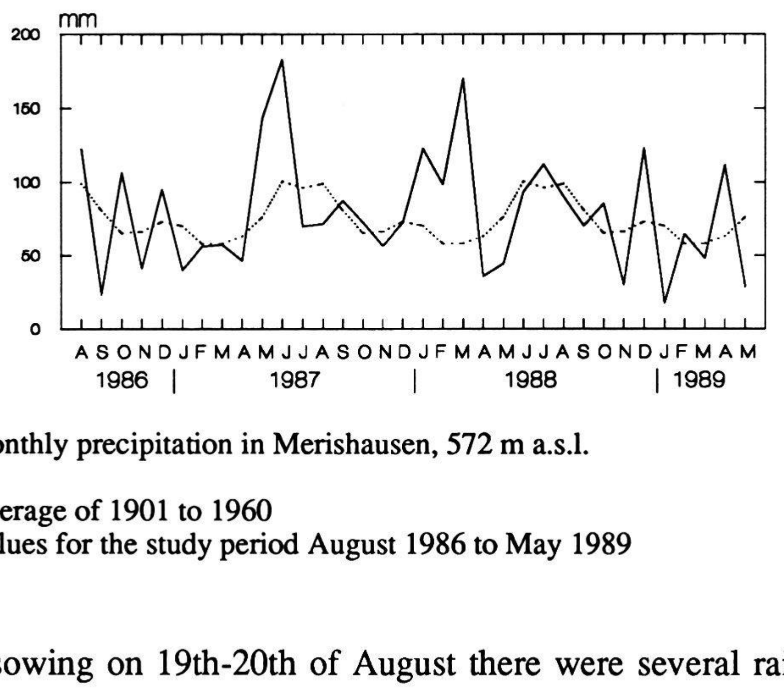

Fig. 2b. Monthly precipitation in Merishausen, 572 m a.s.l.

.... Average of 1901 to 1960
——— Values for the study period August 1986 to May 1989

After the sowing on 19th-20th of August there were several rainy days and during the whole autumn the intervals without precipitation were not longer than 2-5 days, except once in mid-September 11 days. The whole autumn was warm, especially September with a mean temperature of 16.5°C, 3.5°C above average.

1988. The winter was warm and, except for a few days with some snow-fall, there was no snow before the end of February. The snow-cover of a couple of centimeters lasted only a short time, until the beginning of March. The rainy and cool March was followed by very dry warm April and May. Summer was warmer than average with phenological development 1-2 weeks ahead. The day of the mowing (20th of July) and the following 4 days were without pre-

cipitation and temperatures were high (max. 33.2°C). The drying out of the soil was facilitated also by a breeze. The fairly dry and warm autumn was followed by a cold November with some snow during a couple of days.
1989. The winter was again exceptionally warm. It snowed only on 3 days and a lasting snow-cover was missing. March was warm, 4°C above average, April cool and rainy.

2.3. EXPERIMENTAL DESIGN

Germination, establishment of the seedlings and the subsequent survival as well as growth of the juvenile plants were studied in microsites, which were differently influenced by the neighbouring adult plants. For that purpose plots were created, each plot consisting of an area of 15x30 cm where all the aboveground vegetation including mosses and litter was removed, except one mature plant in the middle, further called the central plant. Seeds were sown in a line through the central plant and the adjacent gaps. The fate of the emerged seedlings in the different microsites was recorded.
The plots were orientated in north-south direction. Consequently one plot consisted of a central plant and gaps of 100-200 cm^2 on the north side as well as on the south side of the central plant (Fig. 3). As central plants three species common in the meadow were chosen: *Bromus erectus, Onobrychis viciifolia* and *Salvia pratensis* (description in Chapter 2.4).
For analysis the plots were divided into three different microsites depending on the degree of influence of the central plant (Fig. 3):
Tuft-microsite. Seedlings growing in the dense vegetation of the tussocks of *Bromus erectus* or *Onobrychis viciifolia* were assigned to that microsite. The seedlings were rooted between the tillers or stems of the central plant. On plots with *Salvia pratensis* as central-plant no tuft-microsite was separated, because of the rosette growth of *Salvia.*
Edge-microsite. Seedlings at the edge of the central plants not clearly growing in the tuft or in the gap were assigned to this approximately 2 cm wide microsite.
Gap-microsite. Seedlings growing at a distance of about 1 cm or more to the central-plant were assigned to the gap-microsite. Seedlings growing nearer than 2 cm to the surrounding vegetation were not included in the study and were pulled out.
In relation to the height of the vegetation in June-July the gaps were rather

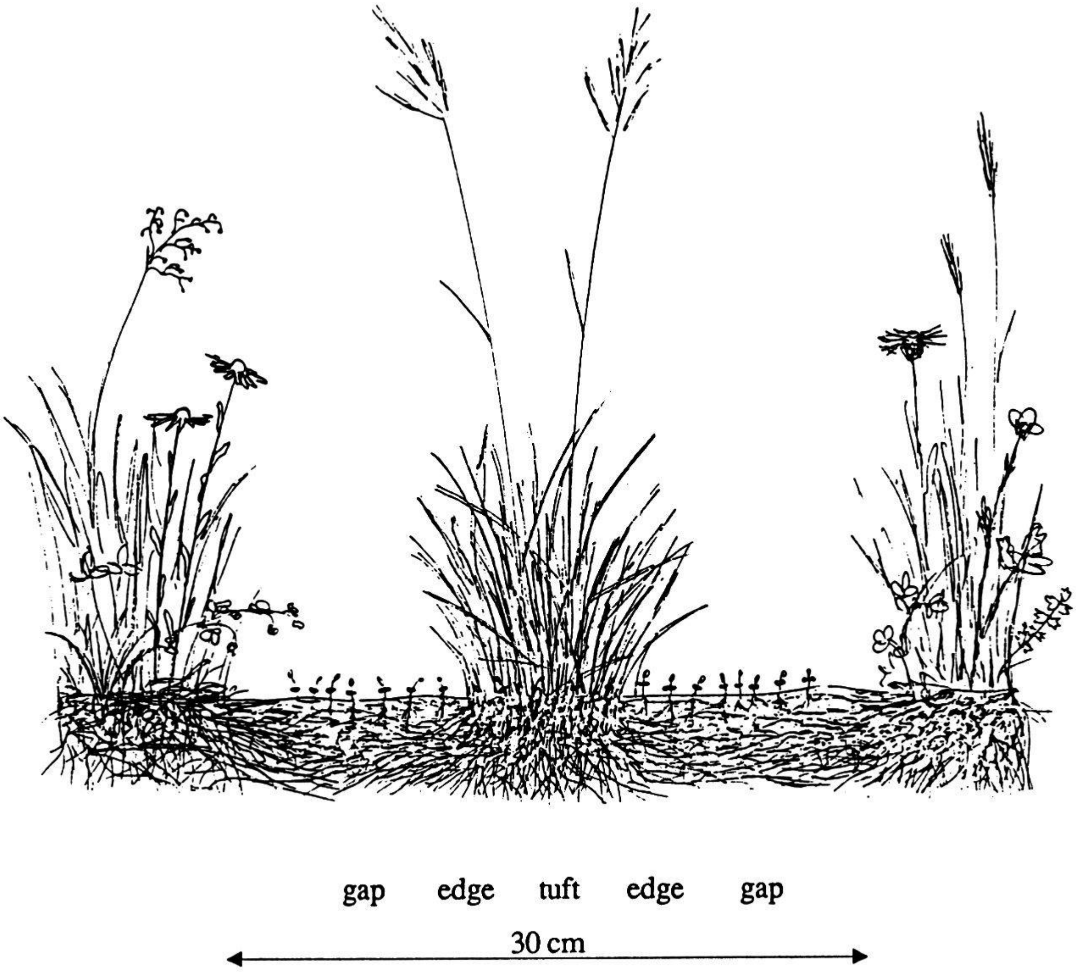

Fig. 3. Schematic view of a plot with *Bromus erectus* as central plant and the different microsites.

small and their environmental conditions were strongly influenced by the surrounding vegetation and the central plant. Besides the above-ground effects there was also a strong below-ground influence by the roots.
Salvia-rosettes had a smaller diameter at the ground-level than the tussocks of *Bromus* and *Onobrychis*, which resulted in a larger gap size in *Salvia*-plots (ca. 13x15 cm) than in the other plots (ca. 8x15 cm).
Further, the influence of the mosses on the establishment was studied. For that purpose separate plots were created, each consisting of two gaps of 15x15 cm close to each other, where all phanerogamic vegetation was removed. One of the gaps had a moss cover and the other was bare. The distance between these two gaps was 5-30 cm.
The microsites concerning the influence of moss cover are called here:

Moss-covered microsite. The moss cover consisted of a loose, 1-1.5 cm thick layer of pleurocarpic species, mainly *Homalothecium lutescens*, *Abietinella abietina* and *Thuidium delicatulum*. (Nomenclature of the mosses follows FRAHM and FREY 1983).
Bare microsite. The bare microsites were similar to gaps around central-plants, but slightly larger.
The vegetation was removed by cutting the plants with a knife as deep as possible without disturbing the topsoil too much. Easily removable rhizomes were pulled out. After their removal the soil surface was smoothed. The gaps were preferably created on sites with natural gaps or sparse vegetation. All the plots were distributed on an area of about 10x10 m with a slight slope towards the east.
Species sown on the plots were *Arabis hirsuta, Linum catharticum, Medicago lupulina, Plantago lanceolata, Primula veris* s.l. and *Sanguisorba minor*. The species are described in chapter 2.4. Seeds of each species were sown on 5 replicate plots of each of the 4 types of plots. These seeds were collected around the experimental plots during the first half of July just before the mowing and sown on the plots in August after the mowing.
The plots were prepared in August 1986. Seeds were sown on the 27th-30th August 1986 and again on 19th-20th August 1987. In the first year 60 seeds were sown on each plot (45 seeds of *Sanguisorba minor*), in the second year 100 seeds on the same plots. The plots were inspected at intervals of 2-8 weeks during the growth season, from April to November. Emerged seedlings and their position were recorded. The survival of previously recorded seedlings was controlled. If a previously recorded seedling or young plant was not found in a given position or very close to it, it was regarded as dead. In some cases seedlings having disappeared above-ground had still viable roots and reemerged. These plants could be distinguished from new seedlings, as they had no cotyledons. Seedlings of other species than the sown one, and shoots and stolons from the neighbouring vegetation sprouting in the gaps were removed at recordings.
The position of the seedlings was determined by two or more fixed points on the plot and a 1 cm grid scratched on plexiglass. The plexiglass was positioned with the help of fixed points and the coordinates could be read by looking through the grid. To avoid parallax, the 1 cm thick glass had the grid on both sides. If seedlings were growing close to each other, they were thinned until the distances between the seedlings were not less than about half a centimeter to make identification with the coordinates possible. As an addi-

tional help for the identification of seedlings of different age growing close to each other, plastic rings cut from straws were used to mark them. During the winter some seedlings moved around as a consequence of soil movement, but with some exceptions it was still possible to recognize them individually.
The fate of the seedlings was followed from emergence until September 1988 or for *Arabis hirsuta* and *Primula veris* until April and May 1989 respectively.
Further information about the performance of the seedlings in different microsites was gained by measuring the size of the surviving seedlings in August-September 1988. As a non-destructive and rapid estimation of their above-ground biomass, the number of living leaves and the length of the longest leaf was measured.

2.4. ANALYSIS OF THE DATA

Germination behaviour is characterized by the time of emergence, by the total emergence and by comparisons of the number of emerged seedlings in different microsites. The number of emerged seedlings however can be compared exactly only in the moss-covered and bare microsites, as the number of seeds in the microsites around and in the central-plants is unknown because of the variable size of these microsites (see also Chapter 3.1.2).
The establishment of seedlings is characterized by two parameters: survivorship and death rate. Survivorship is the percentage of the total number of seedlings in one cohort still alive at a given date. Death rate is the percentage of seedlings having disappeared since the preceding recording. Intervals between the recordings varied, hence the death rates at different dates do not refer to equal periods.
Beside the number of leaves and the length of the longest leaf, the size of the seedlings in different microsites is compared by the product of these two measurements as a parameter to characterize the above-ground biomass.
For statistical analysis of the data nonparametric tests of SYSTAT software-package were used (WILKINSON 1987). Differences in germination and seedling behaviour between the microsites were tested with Wilcoxon signed ranks test (paired samples). Seedling performance in the plots with different central-plant species as well as the behaviour of the different species sown was compared using the Mann-Whitney test (ZAR 1984).
The number of replicates of each species-combination of sown seed and cen-

tral-plant was five. As the *Bromus*- and *Onobrychis*-plots were similar, separate tests were made for their pooled data. In these cases the number of replicates was 10. In some microsites species with poor emergence and/or high mortality had a lower number of replicates. Data based on less than three replicates is not presented.
As the number of true replicates was low, significance levels up to $p<0.10$ are reported with the results. This gives the reader an impression of the strength of the evidence. The interpretations are not based on individual tests but on consistent trends in different tests.

2.5. SPECIES USED IN THE EXPERIMENT

2.5.1. Description of the species

Six dicotyledonous species common in the local limestone grasslands were chosen to study the early life stages. The following brief description of the species is based mainly on GRIME et al. (1988), HEGI (1908 ff.), HESS et al. (1976-1980), LANDOLT (1977) and ZOLLER (1954b). The given seed weight is that of the seeds weighed in groups of 100, before sowing.
Arabis hirsuta **(L.) Scop.** is a short-lived perennial hemicryptophyte forming a semi-rosette, relatively small in size. Its habitats are infertile meadows and road-verges. The CSR-strategy (GRIME 1979) of *Arabis* is intermediate between stress-tolerator and stress-tolerant ruderal. Its seeds are the smallest of the studied species, 0.13 mg.
Linum catharticum **L.** is a small biennial with erect stems, which occurs in open grassland on calcareous, nutrient-poor soils. The CSR-strategy of *Linum* is a stress-tolerant ruderal. Seeds are small, 0.18 mg.
Medicago lupulina **L.** is a short-lived perennial of a small stature with ascending or procumbent shoots. It is common on dry open habitats, meadows and verges. The CSR-strategy of *Medicago* is characterised as an intermediate between stress-tolerant ruderal and ruderal. Seeds are fairly large, 2.04 mg.
Plantago lanceolata **L.** is a long-lived perennial polycarpic hemicryptophyte forming a rosette with erect, lanceolate leaves. It occurs in a wide range of habitats, mostly in meadows and road-verges, and is able to tolerate dry and nutrient-poor conditions. The CSR-strategy of *Plantago* is intermediate between competitor, stress-tolerator and ruderal. Seeds are relatively large, 1.96 mg.

***Primula veris* L. s.l.** is a long-lived perennial polycarpic hemicryptophyte. The leaves form a basal rosette. WITTWER (1983) describes the subspecies growing at the study site as *Primula veris* L. em. Hudson ssp. *suaveolens* (Bertol.) Gutermann et Ehrend. (= *Primula columnae* Ten.). This subspecies is usually found in shadier habitats, such as light woods, and its occurrence in an open meadow as on the Gräte is rather uncommon. It is able to tolerate dry conditions better, but requires somewhat more nutrients than the subspecies *veris*, which is a typical plant of nutrient-poor meadows.
The population on the Gräte shows great variation. It occurs in the meadow as well as in the adjacent wood, individuals growing in the shade being markedly larger than those in open sites. Because of this variation and the diffuse systematics of the subspecies of *Primula veris* with many transitional plants occurring (TUTIN et al. 1964) the taxa studied here is subsequently referred to as *Primula veris* s.l.
The seed size of *Primula* is intermediate (1.07 mg) among the studied species. In contrast to the other species *Primula* was sown only in 1987.
***Sanguisorba minor* Scop.** is a long-lived perennial polycarpic hemicryptophyte with a semi-rosette and an erect stem. It is a typical plant of dry grasslands in the region, occurring also in other open habitats such as road-verges. Its CSR-strategy is stress-tolerant. Seeds are the largest ones of the studied species, 4.86 mg.
The early life stages of the six above-mentioned species were studied in the neighbourhood of common large-growing perennials. Three species with different growth-forms were chosen as such central-plants:
***Bromus erectus* Hudson** is a perennial tussock-forming grass being characteristic for the unfertilized limestone grasslands and dominating the vegetation of the meadow.
***Onobrychis viciifolia* Scop.** is a densely tufted herb occurring on dry nutrient-poor meadows and is common at the study site. As a *Fabaceae* it is able to fix symbiotically atmospheric nitrogen.
***Salvia pratensis* L.** forms large rosettes, which at the study site completely die above-ground during the winter. It is a typical plant in the limestone grasslands.
Bromus forms a dense rooting system around the tussock, whereas *Onobrychis* and *Salvia* have a large tap root and the fine roots near the surface are not so well developed.
The species are subsequently referred to by their genus name. Nomenclature of the vascular plant species follows BINZ and HEITZ (1986).

2.5.2. Population characteristics of the species at the study site

Some characteristics of the species were assessed at the study site. The frequency of the species was measured in July 1987 on 33 samples of 0.25 m^2 arranged along three stripes beside the experimental plots. In 1986 the occurrence of the species was recorded in an area of 50x355 cm with a grid of 5 cm giving the frequency in samples of 25 cm^2. Natural regeneration by seed was recorded on the same, slightly extended (8.625 m^2) stripes from September 1986 to June 1987. In September 1987 the survival of these seedlings was recorded in one third of that area. The data of the seed bank at the study site is from RYSER (1984).

The viability of the seeds sown was tested in autumn 1986 (*Primula*: autumn 1987) in growth chamber (Table 2). One hundred seeds of each species were sown on Petri-dishes with wet blotting-paper and their germination was recorded during 50 days. The temperature regime in the climatic chamber was 20°C (day, 16 hrs.) and 10°C (night, 8 hrs.).

All the species were frequent at the study site (Table 1). In samples of the size of 0.25 m^2 *Arabis* was the only one with a frequency below 90% (61%). With the sample size of 25 cm^2 *Arabis* and *Primula* were the only ones with a frequency less than 10% (3.5% and 8.7% respectively).

All the species were observed also in the seed bank as well as seedlings in the natural vegetation. *Plantago* and *Linum* had the largest seed bank. *Linum* germinated in the natural vegetation in very large numbers but had also a high mortality of seedlings.

Tab. 1. Some attributes of the studied species at the study site.

	Percentage frequency with sampling unit size of		seedlings per m^2 (emerged Sept. 86-June 87)	survivorship of these seedlings in Sept. 1987 (No. of assessed seedlings in parenthesis)	seed weight	seed bank in the topmost 2.5 cm seeds/m^2
	0.25 m^2	25 cm^2				
Arabis hirsuta	61%	3.5%	12	44% (52)	0.13 mg	19
Linum catharticum	100%	40.6%	246	38% (491)	0.18 mg	64
Medicago lupulina	91%	18.0%	36	48% (79)	2.04 mg	13
Plantago lanceolata	100%	23.1%	24	78% (37)	1.96 mg	122
Primula veris	91%	8.7%	7	57% (7)	1.07 mg	13
Sanguisorba minor	100%	15.5%	17	61% (49)	4.86 mg	26