Studies on reproductive behaviour

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3. STUDIES ON REPRODUCTIVE BEHAVIOUR

3.1. METHODS

3.1.1. Experimental pollinations

Material used in breeding experiments was sampled in 1978 (seeds only), 1980 and 1982 (rosettes). The samples originated from various local sectors within the research area (Table 3). The rosettes were chosen at random within their subpopulations and transferred to Zürich, where they were individually potted in garden soil and kept in the greenhouse of the Geobotanical Institute. Of about 60 specimens only 13 were flowering in spring 1983 and could be used for the experiments. Plants used in breeding experiments were tested for their polyploidy level. For this purpose, very young leaves were fixed for at least 24 hrs in a mixture of ethanol and acetic acid (3:1). The squashes were stained with lacto-propionic orcein according to DYER (1963); the same method was used in the previous cytological studies of the present author (GASSER 1981). All specimens studied proved to be tetraploid (2n=4x=36). The results confirm the previous results of the author (GASSER 1981), obtained with the material from the same study area (Fig. 14).

Fig. 14. Metaphase of Biscutella levigata from serpentine (sector SER4), tetraploid level with 2n=4x=36 chromosoms, 1500x, (from GASSER 1981).

Abb. 14. Metaphase von B. levigata von Serpentin (SER 4). Tetraploide Stufe mit 2n=4x=36 Chromosomen.

Observations on breeding behaviour were carried out under the greenhouse conditions. Some plants were left for possible open pollinations, only a few individuals being isolated (control). Forced pollinations were carried out in three series:

a) pollinations with the pollen of the same individual;
b) pollinations with pollen from plants growing on the same substratum within the same and/or other subpopulations;
c) pollinations with pollen from plants originating from other substrata.

The pollinations were made with a small brush, pollen from several flowers of the same plant being taken. In each series five flowers were pollinated and subsequently isolated with gauze. After 1 1/2 months the seeds were harvested and studied further in laboratory and greenhouse.

3.1.2. Germinating behaviour and early life phases

Three aspects were studied:

a) Germinating behaviour under controlled laboratory conditions (Table 3).
b) Germinating behaviour and development of young plants on alpine and garden soil in the greenhouse (Table 4).
c) Germinating behaviour and development of young plants in the field (Table 5).

In the field, fruits were harvested in September 1980 (sectors DOL 6, SER 4, 5) and in September 1981 (sectors DOL 6, DOL 3, 7, 10, DOL 5, 8, SER 1, SER 4, 5, SER 3, 7, 10). Each sample consisted of fruits from several flowering shoots chosen at random.

Fruits, collected directly from plants, were dried at room temperature for several days and stored in paper bags also at room temperature, or in the refrigerator at 4°C. Prior to sowing, the pericarp was removed and well developed seeds were selected.

Laboratory experiments (Table 3). Seeds chosen at random were sown onto wet blotting paper in Petri dishes and incubated in a climatic chamber at a temperature regime of 20°C (Day, 13 hrs) and 10°C (Night, 11 hrs.). The relative air humidity was 80%. The samples were scored for germination in the light and in the dark, germination being defined as the stage where the radicle had penetrated the pericarp.

Table 3. Laboratory experiments; seeds sown on blotting paper.
Tab. 3. Klimakammerversuche; Samen ausgesät auf Fliesspapier.

DOL = dolomite, SER = serpentine.

Origin of seeds	N of seeds	Beginning of trial	Duration of trial	Aspect studied
DOL 6	100	10 Oct 80	45 days	germination
SER 4,5	100			in the light
DOL 3,7,10	50	6 Jan 83	67 days	germinating
DOL 5,8	50			behaviour
DOL 6	50			in the light
SER 1	50			
SER 3,7,10	50			
SER 4,5	50			
SIL	25			
DOL 6	10	12 Jan 83	38 days	germination
SER 1	10			in the dark

Table 4. Greenhouse studies.
Tab. 4. Gewächshausversuche.

DOL = dolomite, SER = serpentine, SIL = acidic silicate.
* Seeds in these series were sown on blotting paper in the climatic chamber; young plants were subsequently potted into garden soil and transferred to the greenhouse.
** Number of leaves was counted in 20 plants chosen at random.
*** Individual development was observed in all young plants developed.

Origin of seeds	N of seeds or plants	Beginning of trial	Duration of trial	Substratum	Aspect studied
DOL 6	100	18 Mar 81	177 days	dolomite	germinating
SER 4,5	100			soil	behaviour
DOL 6	100	24 Mar 81	171 days	serpentine	N of leaves**
SER 4,5	100			soil	
DOL		7 May 83	13 weeks	garden	leaf area
3,5,6,7,	10			soil	
8,10					
SER					
1,3,4,5,	10				
7,10					
SIL	2				
DOL 6	8	3 Feb 81	22 months	garden	weight of plant
SER 4,5	8			soil*	N of rosettes
experiment.	159	18 Oct 83	9 months	garden	germination
pollination				soil*	individual***
					development

Table 5. Field observations.
Tab. 5. Feldversuche.

DOL = dolomite, SER = serpentine.
* number (N) of leaves, height, and diameter of rosettes were investigated in the best developed plants.

Origin of seeds	N of seeds	Beginning of trial	Duration of trial	Substratum	Aspect studied
DOL 6	100	7 Oct 80	4 years	DOL developed soil	N of plants
SER 4,5	100				N of leaves*
DOL 6	100			SER developed soil	height and diameter of rosettes*
SER 4,5	100				
DOL 3,7,10	50	30 Sep 82	2 years	DOL scree	N of plants
DOL 4,5	50				N of leaves*
DOL 6	50				height and diameter of rosettes*
SER 1	50				
SER 3,7,10	50				
SER 4,5	50				
DOL 3,7,10	50			SER scree	
DOL 4,5	50				
DOL 6	50				
SER 1	50				
SER 3,7,10	50				
SER 4,5	50				

Observations on germinating behaviour of seeds developed after experimental pollinations were carried out under the same conditions. All seeds obtained were used.

Greenhouse studies (Table 4). Greenhouse trials were carried out in four series:

1) Seeds were sown in two trays (50 cm x 35 cm x 6 cm), one filled with dolomite soil and the other with serpentine soil brought from the study area. 100 seeds from dolomite and 100 seeds from serpentine in four rows per tray were sown in either tray. Seedlings and young plants were counted once a week; the number of leaves was counted once a week in twenty plants chosen at random.

2) In the second series flower pots (diameter 9 cm, height 9 cm) filled with garden soil were used. Two seeds each originating from dolomite, serpentine or acidic silicate were put into each pot. After germination, only one plant per pot was left for study of leaf area under competition-free conditions.

3) In the third series, 16 young plants obtained from seeds that origin-

ated from dolomite or serpentine were individually potted into garden soil. After 22 months they were taken out and washed; the number of rosettes per plant and the fresh weight of the whole plant were determined.

4) Young plants obtained from experimental pollinations were individually potted into garden soil and further development was studied.

Field observations (Table 5). In 1980, two experimental plots were established one on dolomite near the sector DOL 1 and one on serpentine within the sector SER 4 (Fig. 1). Prior to sowing, the existing vegetation was removed. In the serpentine plot, the soil was stabilised by burying wire netting perpendicular to the slope to a depth of 20 cm. A 1 m high wire fence was built to protect the trial surfaces from grazing animals. The experimental plot on dolomite was only marked with plugs and the seedlings were protected against grazing by wires laid loosely on the soil.

In 1982, two additional experimental plots were established on dolomite and on serpentine scree (Fig. 1). These trial surfaces were protected from rockfall and erosion by a light metal frame covered with wire netting.

The number of seedlings and young plants, the number of leaves, and the height and diameter of the rosettes in the field experiments were determined roughly once a month throughout a given vegetation period.

3.1.3. Transplantations in the field

At the beginning of September 1982, two additional experimental plots were set up near those established in 1980 (Fig. 1). They were protected from grazing animals by a wire fence. Material used in transplantations consisted of both reproducing and non-reproducing rosettes, but the inflorescences of reproducing rosettes were removed. In all, 200 specimens from the four local sectors DOL 7, DOL 8, SER 3, and SER 4 were planted in the two plots in block design (Fig. 15). Twice 50 rosettes originated from foreign substratum whereas 2 x 50 rosettes from the same substratum represented the control.

The transplantation plots were watered twice in September 1982. During 1983 and 1984 the reproducing and non-reproducing rosettes were scored once a month.

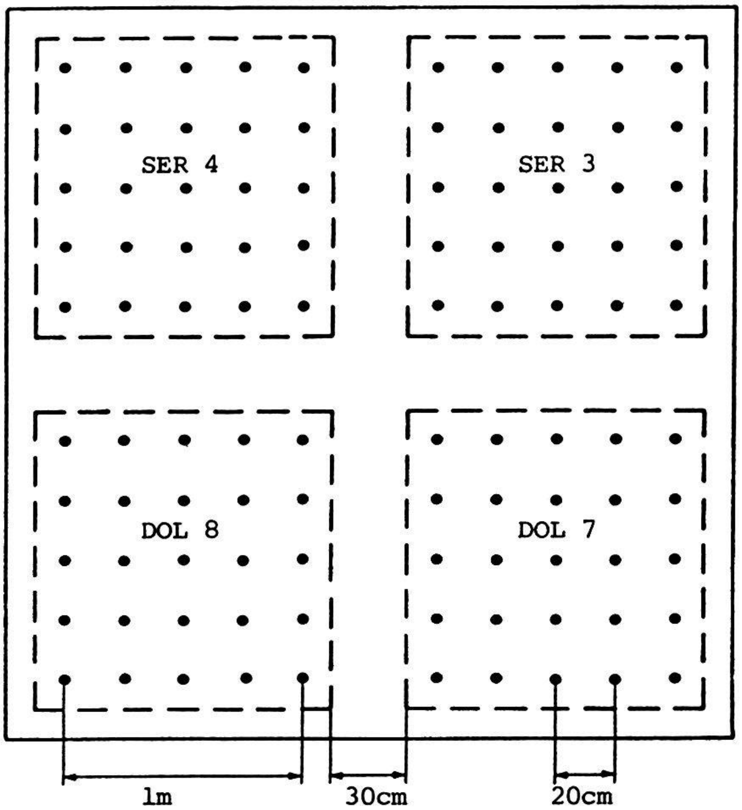


Fig. 15. Design of the transplantation experiments, marked with G in Fig. 1.
Codes (SER 4, SER 3, DOL 8, DOL 7) refer to the origin of the material used.

Abb. 15. Anordnung des Verpflanzungsexperiments, in Abb. 1 mit G markiert.
Abkürzungen beziehen sich auf die Herkunft des Materials.

Exemplified by the plot on serpentine:
upper squares = plants from the same substratum (control)
lower squares = plants from foreign substratum
obere Quadrate = Pflanzen vom gleichen Substrat
untere Quadrate = Pflanzen vom fremdem Substrat

3.2. RESULTS

3.2.1. Experimental pollinations

Selfings. In open pollinations (control series), fruit and seed development was very seldom observed.
In forced selfings (Table 6), only two plants from dolomite, and a single one from serpentine developed fruit. The seeds obtained from

dolomite plants had a relatively low germination capacity whereas the only seed developed by the plant from serpentine did not germinate.

Cross-pollinations. All pollinated plants developed fruit and seeds; fruit and seed production was usually good (Table 7).
Crosses between plants originating from the same substratum resulted in a high fruit and seed output; the seeds germinated well. More complex results were obtained in crosses between plants from various substrata. When plants from dolomite were female parents and the pollen donors originated from serpentine, the crosses were very successful. In the reciprocal cross combination, however, both the fruit and seed output as well as the germination capacity of seeds were reduced (Table 7).

Table 6. Fruit and seed output in forced selfings.
Tab. 6. Früchte- und Samenproduktion bei den forcierten Selbstungen.

DOL = dolomite, SER = serpentine

Origin	N of pollinated plants	N of pollinated flowers	N of plants producing fruit	N of fruits	N of seeds	Germination
DOL	5	25	2	8 32%	7 14%	4 57%
SER	5	25	1	1 4%	1 2%	0 0%

Table 7. Fruit and seed output in cross pollinations.
(Female parent listed first).
Tab. 7. Früchte- und Samenproduktion bei den Kreuzbestäubungen.
(Weiblicher Elternteil zuerst aufgeführt).

DOL = dolomite, SER = serpentine

Cross combination	N of poll. shoots	N of poll. flowers	N of shoots producing fruit	N of fruits	N of seeds	Germination
DOL x DOL	4	20	4	17 85%	28 70%	28 100%
SER x SER	6	30	6	24 80%	43 72%	32 78%
DOL x SER	5	25	5	20 80%	35 70%	28 80%
SER x DOL	5	25	5	14 56%	23 46%	11 48%

The results obtained demonstrate that Biscutella levigata is predominantly allogamous, with self-incompatibility barriers operating at both pre- and early post-zygotic stages. A slight reduction in fruit and seed output noted in some experimental crosses might be influenced by local racial differentiation.

3.2.2. Germinating behaviour and early life phases

Laboratory experiments. Germinating behaviour of seeds from various alpine substrata followed the same general pattern. Germination started four to six days after the beginning of incubation and most seeds germinated within the first 20 days of the trial (Figs 16, 17).
The high germination percentages in all series were very similar, the average values being almost identical (Table 8).
Germination trial in the dark was run as a supplementary experiment, only a very limited number of seeds being used. They germinated to 40-50% (Table 8).

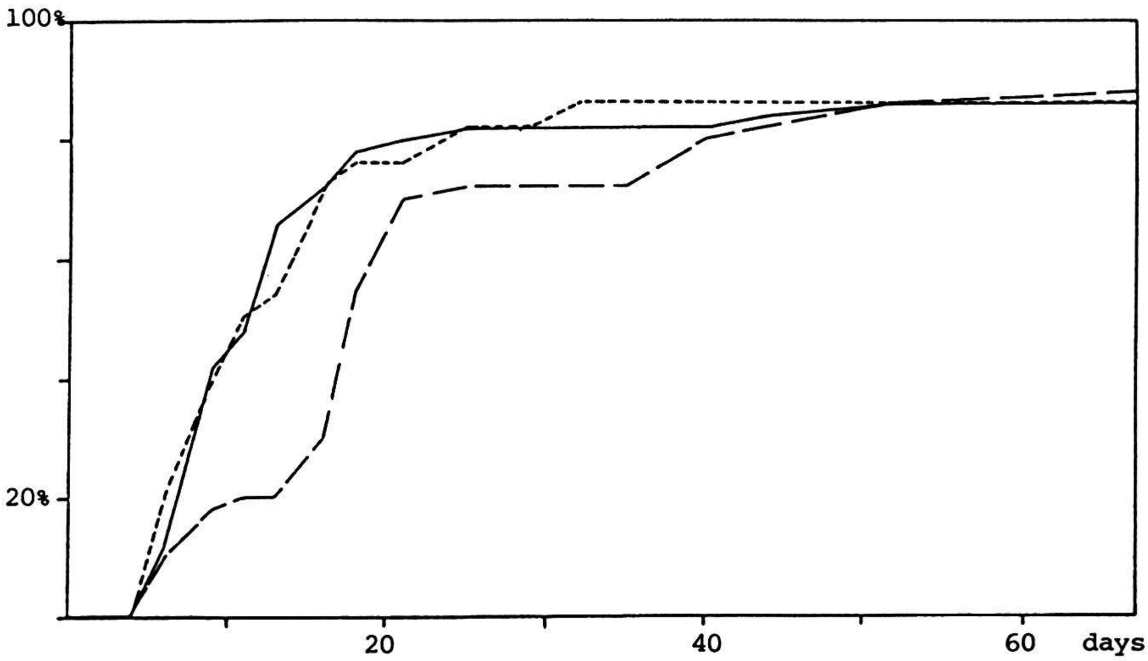


Fig. 16. Laboratory experiments: Germinating behaviour of Biscutella levigata from different local sectors on dolomite (50 seeds per series).
Abb. 16. Klimakammerversuche: Keimungsverhalten von B. levigata aus verschieden Dolomitflächen.

DOL 3, 7, 10: — — — — DOL 5, 8: ———————— DOL 6: --------

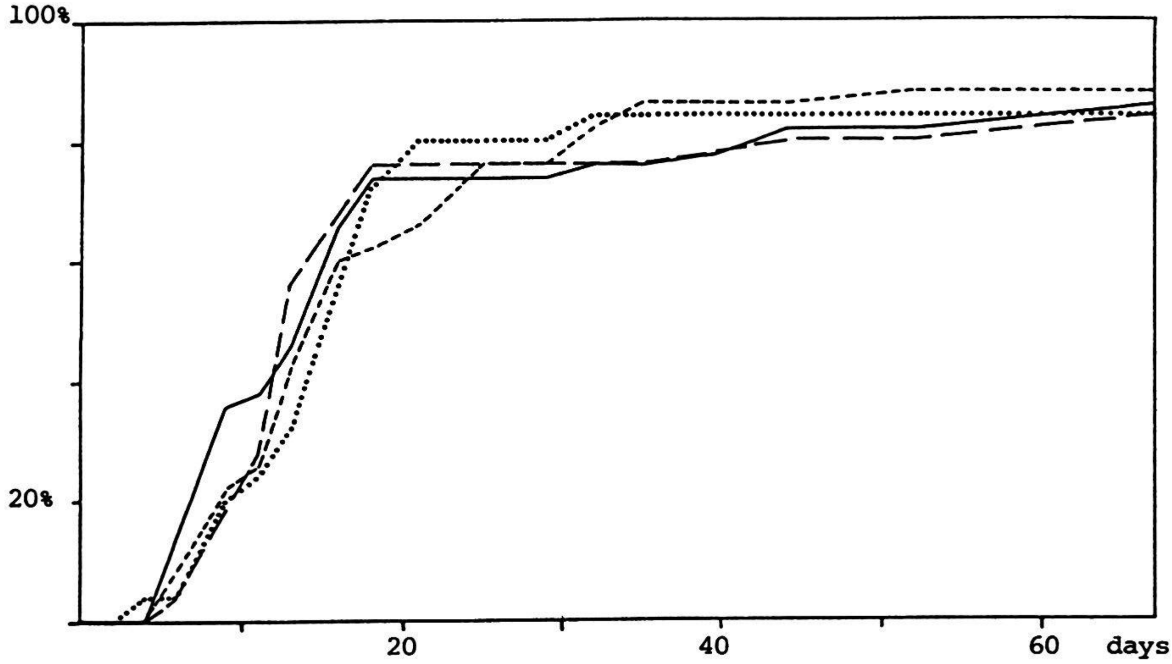


Fig. 17. Laboratory experiments: Germinating behaviour of Biscutella levigata from different local sectors on serpentine (50 seeds per series) and from acidic silicate (25 seeds per series).
Abb. 17. Klimakammerversuche: Keimungsverhalten von B. levigata aus verschieden Serpentinflächen und aus saurem Silikat.

SER 1: ——— SER 3, 7, 10: — — — SER 4, 5: ----- SIL: ....

Table 8. Laboratory experiments: Seed germination.
Tab. 8. Klimakammerversuche: Samenkeimung.

DOL = dolomite, SER = serpentine, SIL = acidic silicate
* Germination in the dark

Origin of seeds	N of seeds	Germination %
DOL 6	100	91
DOL 3,7,10	50	88
DOL 5,8	50	86
DOL 6	50	86
DOL 6	10	40*
SER 4,5	100	92
SER 1	50	86
SER 3,7,10	50	84
SER 4,5	50	88
SER 1	10	50*
SIL	25	84
Total:		
DOL	260	86.5
SER	260	86.9

Greenhouse studies. Seeds from dolomite and serpentine sown on dolomite and serpentine alpine soils began to germinate about one week after sowing. Germination percentages were lower than those obtained under laboratory conditions (Figs 18, 19, Table 9). The best germination (52%) was noted in seeds from dolomite sown on dolomite soil. On the other hand, seeds from serpentine sown on serpentine soil germinated only to 38%. Seeds from dolomite sown on serpentine soil and those from serpentine sown on dolomite soil had a germination rate of 36-38%.

The mortality rate of seedlings and very young plants studied in the same trial was mostly between 21% and 26%; only the plants from dolomite grown on serpentine soil showed a higher mortality viz. 40% (Table 9). Usually the plants died before reaching the age of 40 days (Fig. 18), but mortality of specific ages was not studied in detail.

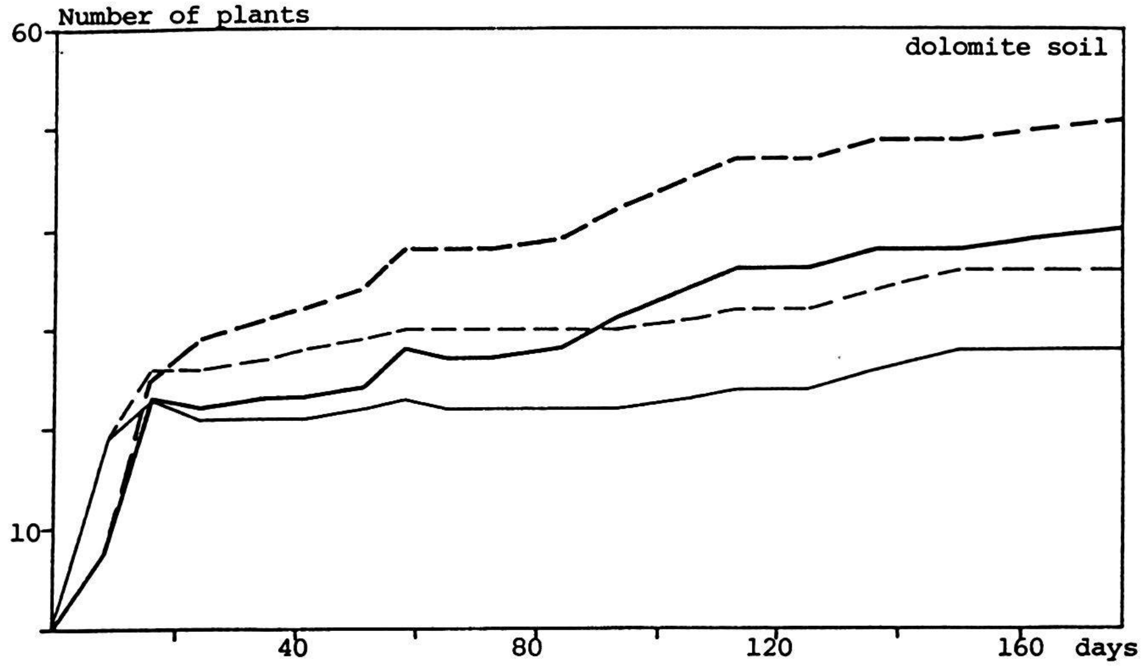
The biomass accumulation at early life phases was assessed by the following parameters: number of leaves, area of leaf, fresh weight of plant, and number of rosettes.

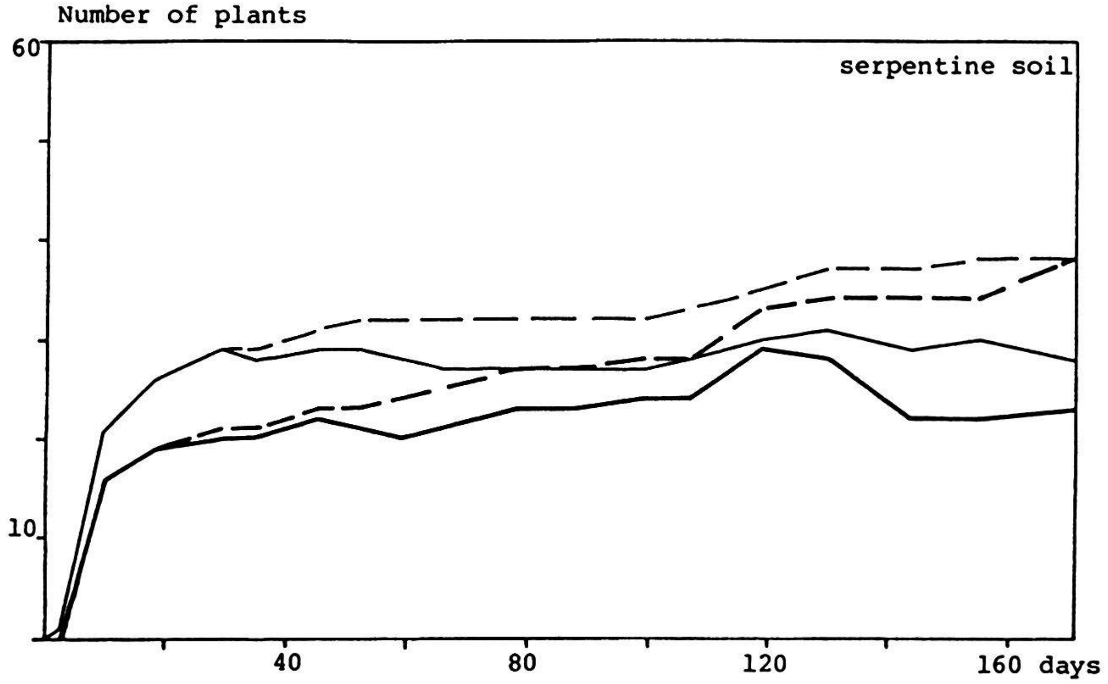
The number of leaves was counted in twenty young plants chosen at random. The plants grown on dolomite soil showed good development regardless of the origin of seeds. The number of leaves increased continuously, the standard deviation being very high at an age of more than 100 to 120 days. On the other hand, the development of plants grown on serpentine soil was significantly slower and almost stopped at an age of more than 100 days (Figs 20, 21, Table 10). Also in this series, the actual origin of seeds had no significant effect on the behaviour of young plants.

Table 9. Greenhouse studies: Seed germination and mortality at early life phases (100 seeds per series).

Tab. 9. Gewächshausversuche: Samenkeimung und Sterblichkeit junger Lebensphasen.

Substrata	Dolomite		Serpentine	
Seed origin	DOL	SER	DOL	SER
Germination	52%	36%	38%	38%
Mortality	21%	22%	40%	26%

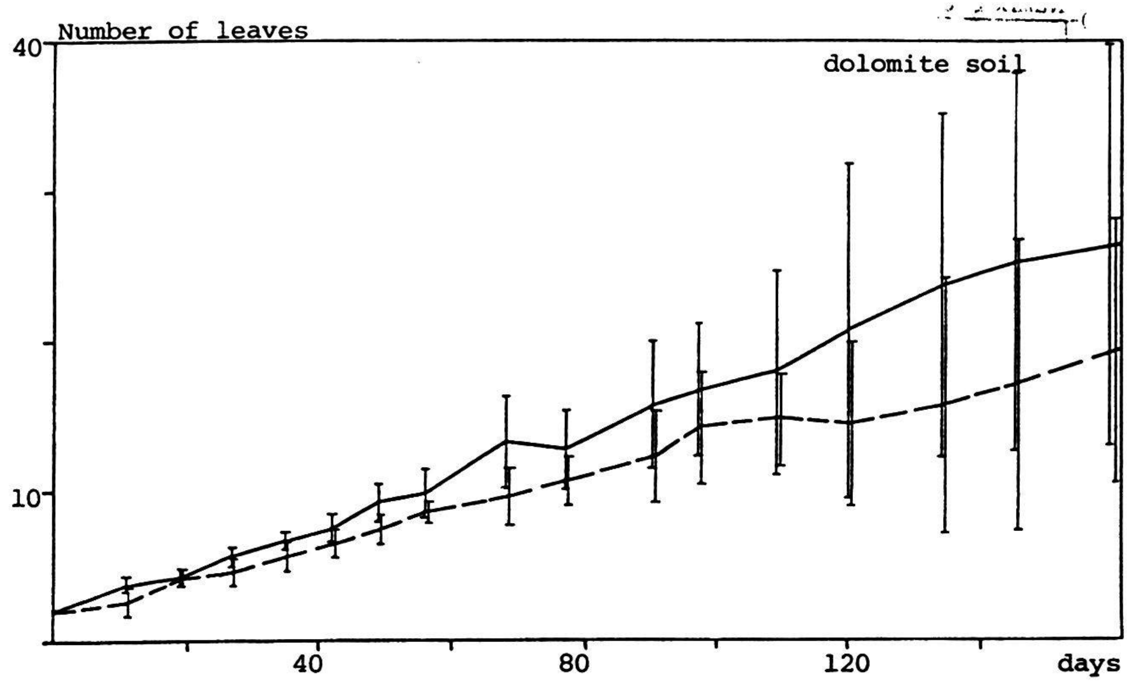


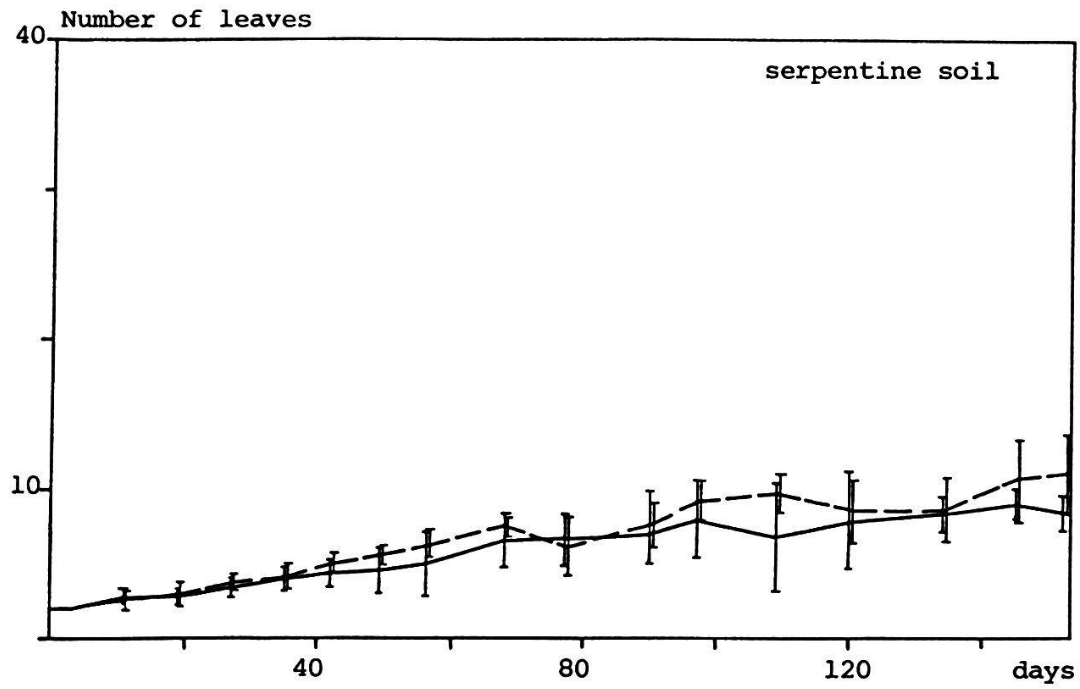


Figs 18,19. Greenhouse studies: Net number (solid line) and cumulative gains (dashed line) of seedlings / young plants on dolomite and serpentine soil (100 seeds per series).

Abb. 18,19. Gewächshausversuche: Nettoanzahl (ausgezogene Linie) und kumulativer Zuwachs (gestrichelte Linie) von Keimlingen / Jungpflanzen auf Dolomit- und Serpeninerde.

Plants from dolomite: ———— , — — — — —
Plants from serpentine: ———— , — — — — —

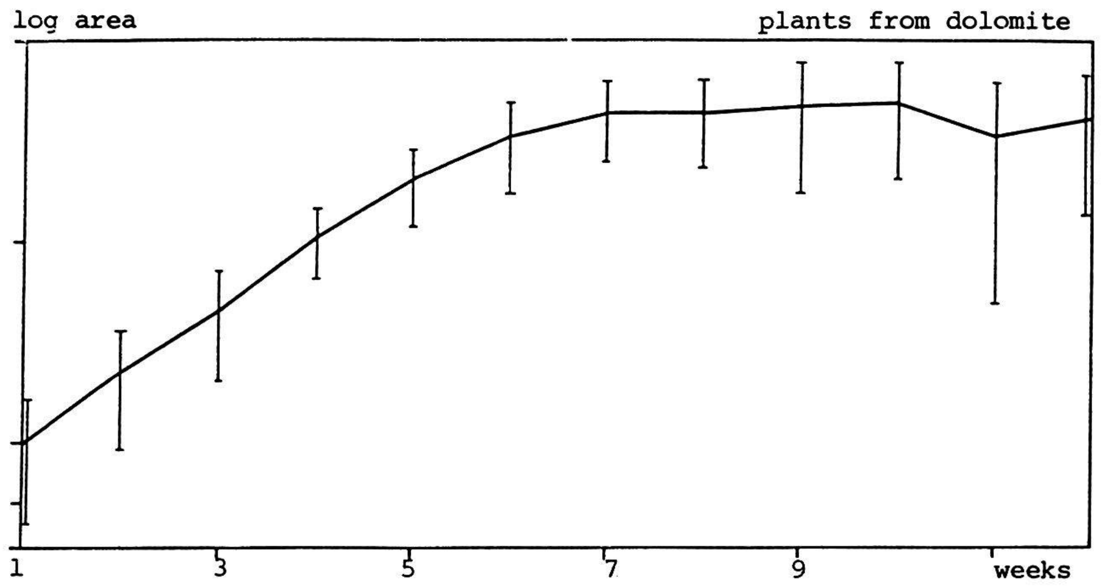


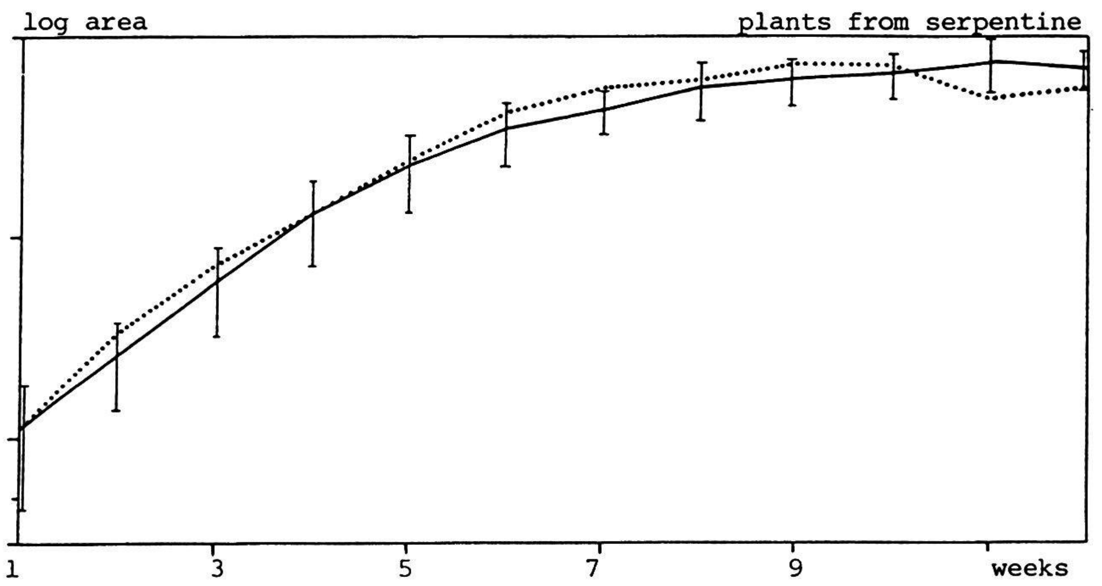


Figs 20,21. Greenhouse studies: Mean number of leaves (± S.D.) in 5 young plants from dolomite and from serpentine grown on dolomite and sepentine soil.

Abb. 20,21. Gewächshausversuche: Mittlere Anzahl Blätter (± s_x) von 5 Jungpflanzen von Dolomit und von Serpentin gewachsen auf Dolomit- und auf Serpentinerde.

dolomite ———————— serpentine — — — — —





Figs 22,23. Greenhouse studies: Leaf area (length x width) (± S.D.) in 10 young plants from dolomite and from serpentine and in 2 plants from acidic silicate (dotted line) grown on garden soil.

Abb. 22,23. Gewächshausversuche: Blattfläche (Länge x Breite) (± s_x) von 10 Jungpflanzen von Dolomit und von Serpentin und von 2 Pflanzen von saurem Silikat gewachsen auf Gartenerde.

Table 10. Greenhouse studies: Development of young plants; analysis of variance of number of leaves.
Niveau of significance of differences between the substrata (dolomite and serpentine) used in the trials and origin of plants (dolomite and serpentine) are indicated.

Tab. 10. Gewächshausversuche: Entwicklung von Jungpflanzen, Varianzanalyse der Anzahl Blätter. Signifikanzniveau der Unterschiede zwischen den Substraten und den Herkünften sind angegeben.

** differences highly significant (P < .01)
* differences significant (.05 > P > .01)
- differences not significant (P > .05)

Days	0	11	19	27	35	42	49	56	68	77	90	109	120	134	145	153
Differences between substrata and origins	**	*	**	**	**	**	**	**	**	**	**	**	*	*	*	*
Differences between the substrata	-	-	**	**	**	**	**	**	[illegible]	**	**	**	**	**	**	**
Differences between the origins	**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

The leaf area defined by length x width of leaves was determined in ten plants grown from seeds originating from dolomite, and in ten plants grown from seeds originating from serpentine. The leaf area in all series increased logarithmically during the first five to six weeks. Later on, the growth slowed down and eventually stopped (Figs 22,23); the mean leaf area of plants from dolomite even decreased. The pattern of development was quite similar in all series studied, no statistically significant differences being found in most cases. Two additional plants from acidic silicate showed the same tendencies.

Fresh weight of the whole plant (PW), and the number of rosettes (NR) were determined in 16 plants grown from seeds originated from dolomite and serpentine. 22-month-old plants grown from seeds originating from dolomite had a higher mean weight with a higher standard deviation than plants grown from seeds originating from serpentine. However, no statistically significant differences occurred between plants of different origins. Variation in the number of rosettes per plant and the ratio weight of plant / number of rosettes (PW/NR) followed the same pattern (Table 11).

Table 11. Greenhouse studies: Development of young plants grown on garden soil (± S.D.).
Tab. 11. Gewächshausversuche: Entwicklung der Jungpflanzen auf Gartenerde (± s_x).

Origin of plants	DOL	SER
Weight of plant PW	15.8g ± 8.95g	12.6g ± 4.40g
N of rosettes NR	19 ± 17.2	8 ± 3.59
Ratio PW/NR	1.56 ± 1.25	1.71 ± .71

Field observations. The experimental plots were located both on developed soil as well as on scree. The percentages of germination on developed soil were nearly the same as those in the greenhouse. On dolomite soil, about 70% of the seeds from both dolomite and serpentine germinated within the first year, whereas on serpentine soil only about 35%

Table 12. Field observations: Minimal rates (%) of germination and mortality on developed soil. Beginning of trial: 7 Oct. 1980 (100 seeds per series) (substrata / origin of seeds).
Tab. 12. Feldversuche: Minimale Keimungsraten und Sterblichkeit auf entwickeltem Boden. (Substratum/Herkunft des Saatguts)
DOL = dolomite, SER = serpentine

Year	DOL/DOL		DOL/SER		SER/DOL		SER/SER	
	germ.	dead	germ.	dead	germ.	dead	germ.	dead
1981	70	18.6	64	39.1	40	40.0	32	12.5
1982	84	33.3	71	66.2	41	63.4	34	17.6
1983	89	43.8	71	100	42	85.7	40	35.0
1984	89	58.4	71	100	42	95.2	41	39.0

Table 13. Field observations: Minimal rates (%) of germination and mortality on scree. Beginning of trial: 30 Sept. 1982 (50 seeds per series) (substrata / origin of seeds).
Tab. 13. Feldversuche: Minimale Keimungsraten und Sterblichkeit auf Schutt.
DOL = dolomite, SER = serpentine

Year	DOL/DOL		DOL/SER		SER/DOL		SER/SER	
	germ.	dead	germ.	dead	germ.	dead	germ.	dead
1983	52.0	78.2	53.3	100	30.0	100	24.7	35.1
1984	57.3	75.6	53.3	100	30.0	100	28.7	74.4

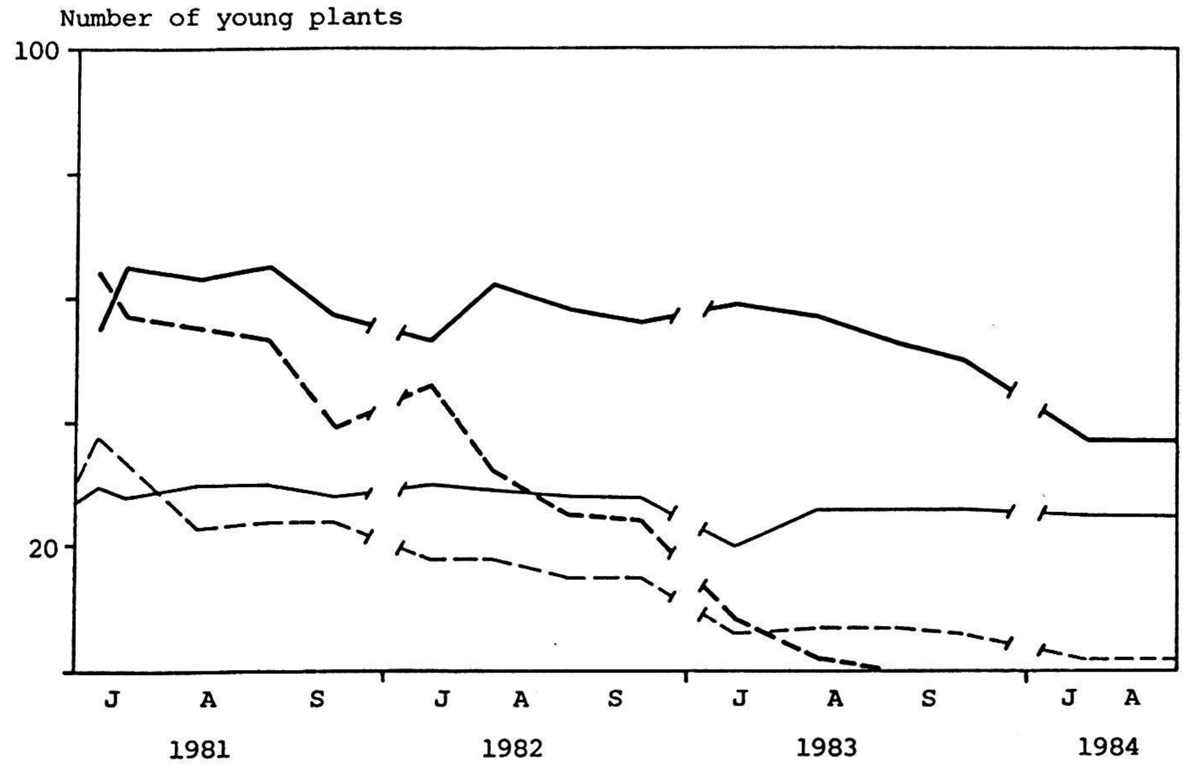


Fig. 24. Field observations: Net number of young plants from dolomite and serpentine grown on developed dolomite (solid line) and serpentine (dashed line) soil (100 seeds per series).
Abb. 24. Feldversuche: Nettoanzahl Jungpflanzen von Dolomit und Serpentin gewachsen auf entwickeltem Dolomit- und Serpentinboden.

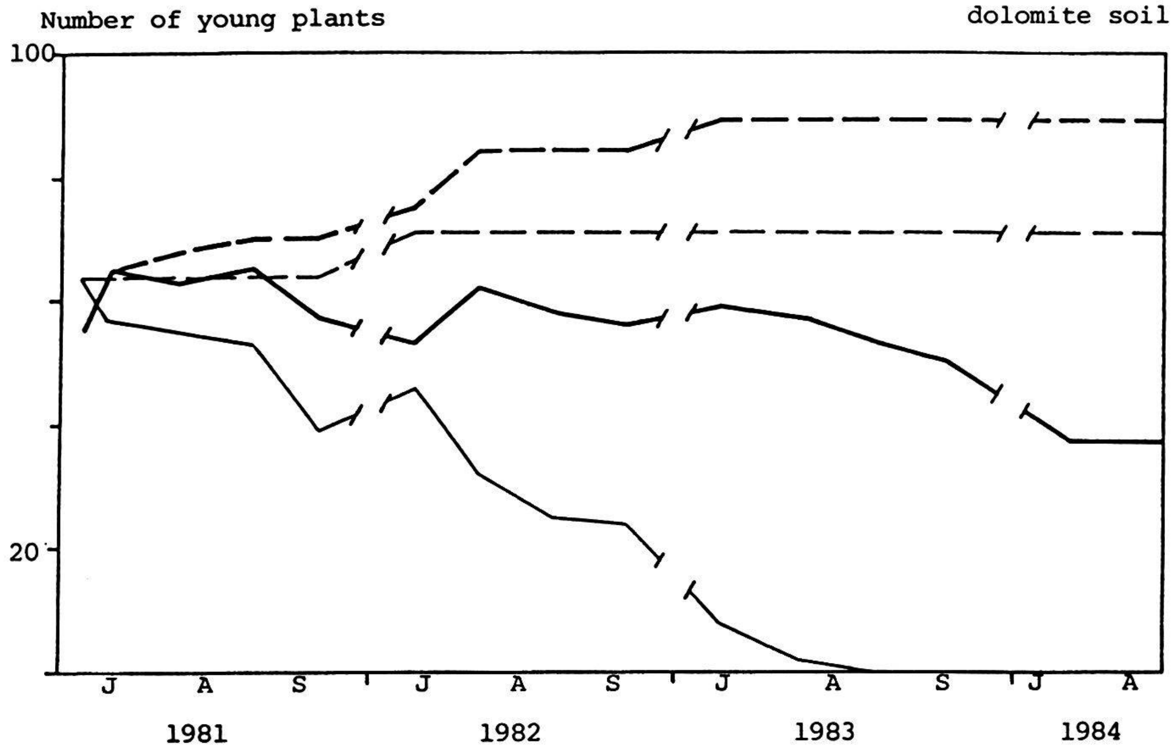
Plants from dolomite: ———, — — , Plants from serpentine: ———, — —

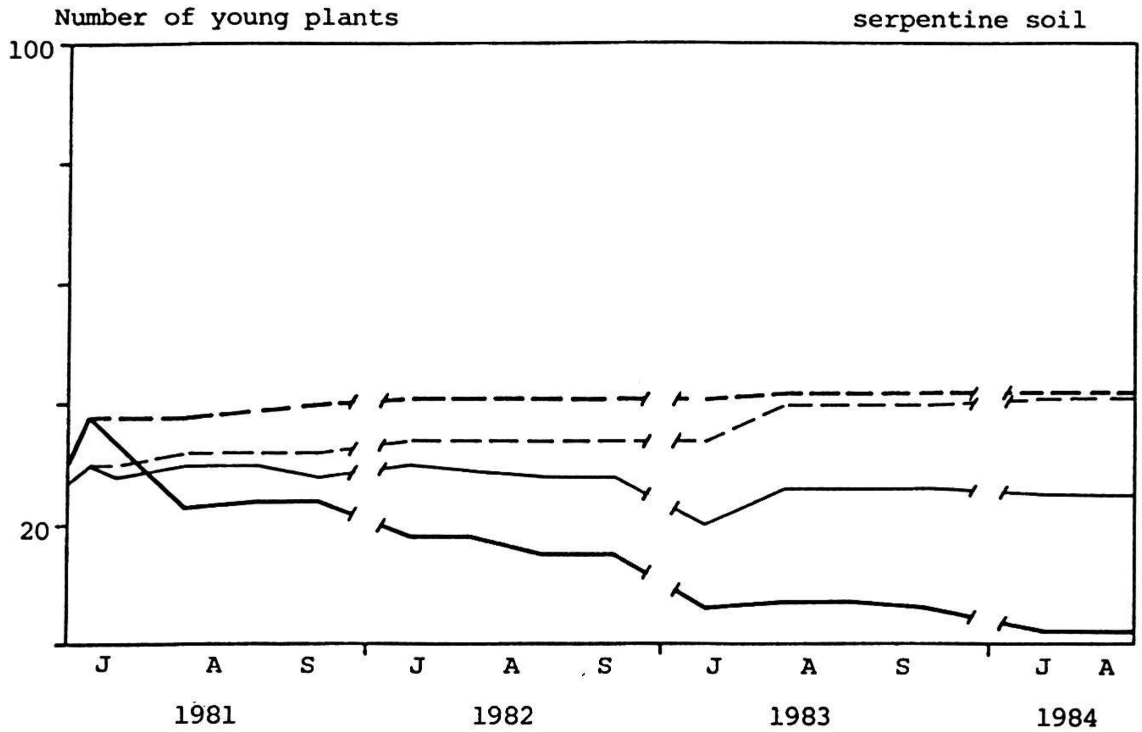
did. In the following years, further seeds germinated (Table 12, Fig. 24).

The germination on scree plots was thus independent of the origin of the seeds. On the whole, germination on dolomite scree was much better than on serpentine. In addition, some differences in germination occurred between seeds from different local sectors (Table 13).

The mortality of seedlings and young plants grown on foreign substrata on developed soil was distinctly higher than that of plants grown on the substratum from which the seeds originated. After four consecutive seasons, all plants from serpentine on dolomite died, and only two plants from dolomite grown on serpentine were still alive (Table 12, Figs 25, 26). At the beginning, however, mortality rates were rather high in all series.

The mortality on scree plots was very pronounced from the very beginning of the trial; individuals growing on the foreign substratum never sur-

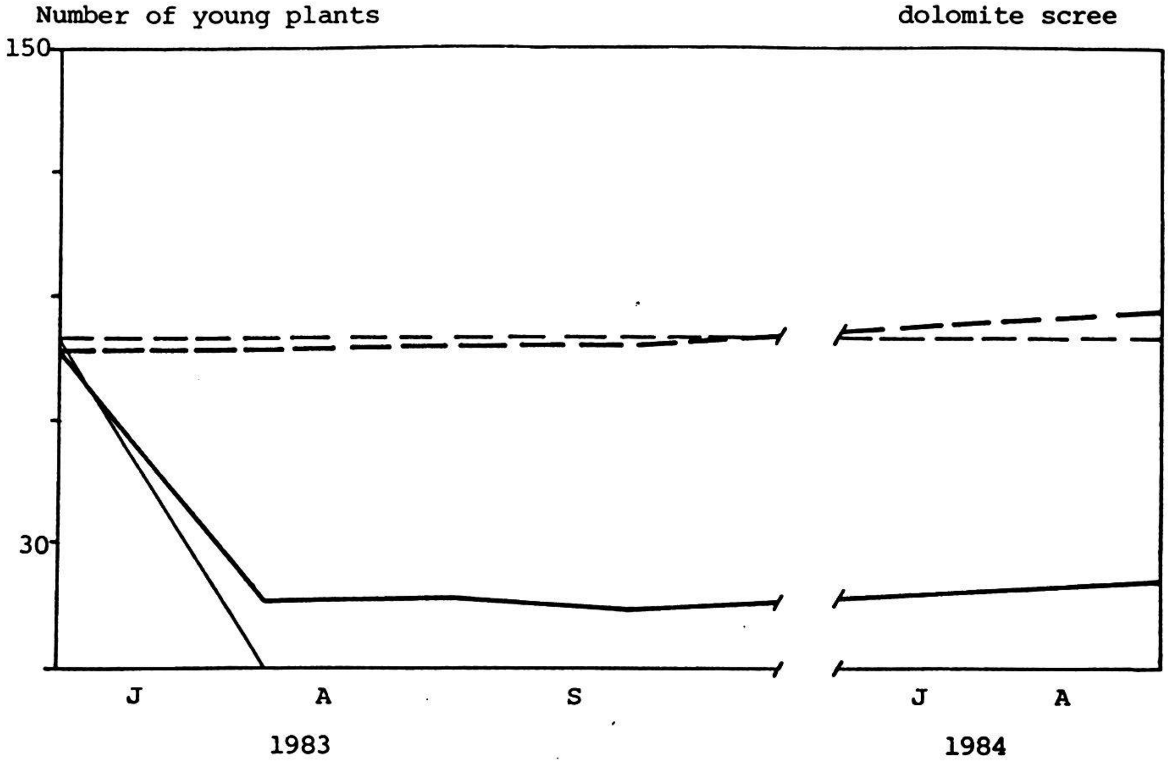


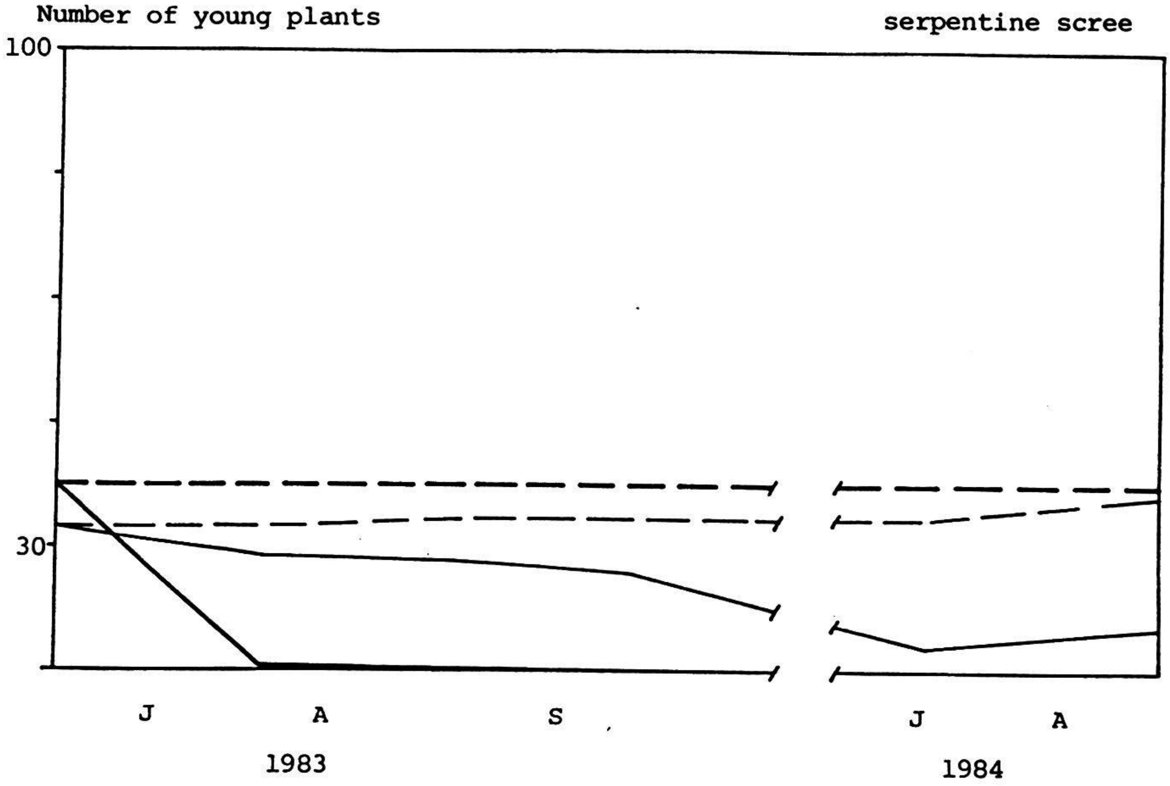


Figs 25,26. Field observations: Net numbers (solid line) and cumulative gains (dashed line) of young plants on developed dolomite and serpentine soil (100 seeds sown per series).

Abb. 25,26. Feldversuche: Nettoanzahl und kumulativer Zuwachs von Jungpflanzen von Dolomit und Serpentin, gewachsen auf entwickeltem Dolomit- und Serpentinboden.

Plants from dolomite: ———— ; — — — — —
Plants from serpentine: ———— ; — — — — —





Figs 27,28. Field observations: Net numbers (solid line) and cumulative gains (dashed line) of young plants on dolomite and serpentine scree (150 seeds sown per series).

Abb. 27,28. Feldversuche: Nettoanzahl und kumulativer Zuwachs von Jungpflanzen von Dolomit und Serpentin, gewachsen auf Dolomit- und Serpentinschutt.

Plants from dolomite: ▬▬▬, ▬ ▬ , Plants from serpentine: ——— , — —

vived the seedling stage, whereas seedlings and young plants growing on the substratum of their origin died to 75%. All the seedlings originating from seeds harvested in the sector DOL 6 died immediately after germination (Table 13, Figs 27, 28).

Table 14. Field observations: Development of seedlings and young plants on developed soil (substrata / origin of seeds).
Tab. 14. Feldversuche: Entwicklung der Keimlinge und Jungpflanzen auf entwickeltem Boden.

N = number of leaves - Anzahl Blätter; h = height - Höhe
d = diameter of rosettes in mm - Durchmesser der Blattrosetten in mm
DOL = dolomite, SER = serpentine

Scored on	DOL/DOL			DOL/SER			SER/DOL			SER/SER		
	N	h	d	N	h	d	N	h	d	N	h	d
5 July 81	5	5	13	3	5	10	4	5	10	4	5	11
1 Sept 81	5	15	16	4	10	12	5	5	10	4	5	12
26 Sept 81	5	20	20	5	10	10	4	5	10	4	10	13
5 July 82	7	20	20	5	13	7	6	10	20	6	20	20
31 July 82	5	20	20	4	12	7	7	10	20	6	40	20
30 Aug 82	6	25	20	5	10	10	6	10	15	6	35	40
28 Sept 82	8	30	20	8	5	7	7	5	15	7	30	30
6 July 83	9	25	20	8	10	8	7	15	20	6	20	15
8 Aug 83	6	30	25	4	10	10	7	20	20	7	30	50
6 Oct 83	6	30	30	-	-	-	2	5	10	6	30	30
1 Sept 84	15	70	70	-	-	-	5	30	15	10	100	50

Table 15. Field observations: Development of seedlingS and young plants on scree soil (substrata / origin of seeds).
Tab. 15. Feldversuche: Entwicklung der Keimlinge und Jungpflanzen auf Schutt.

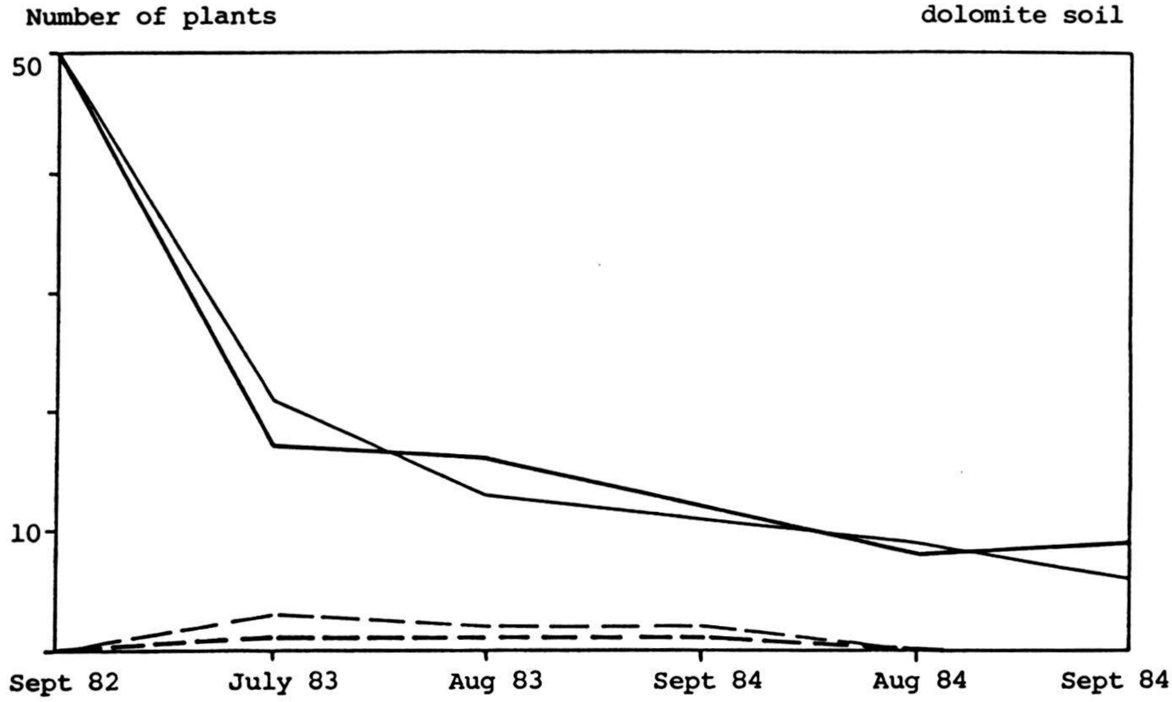
(For abbreviations see Table 24 - Abkürzungen s. Tab. 14)

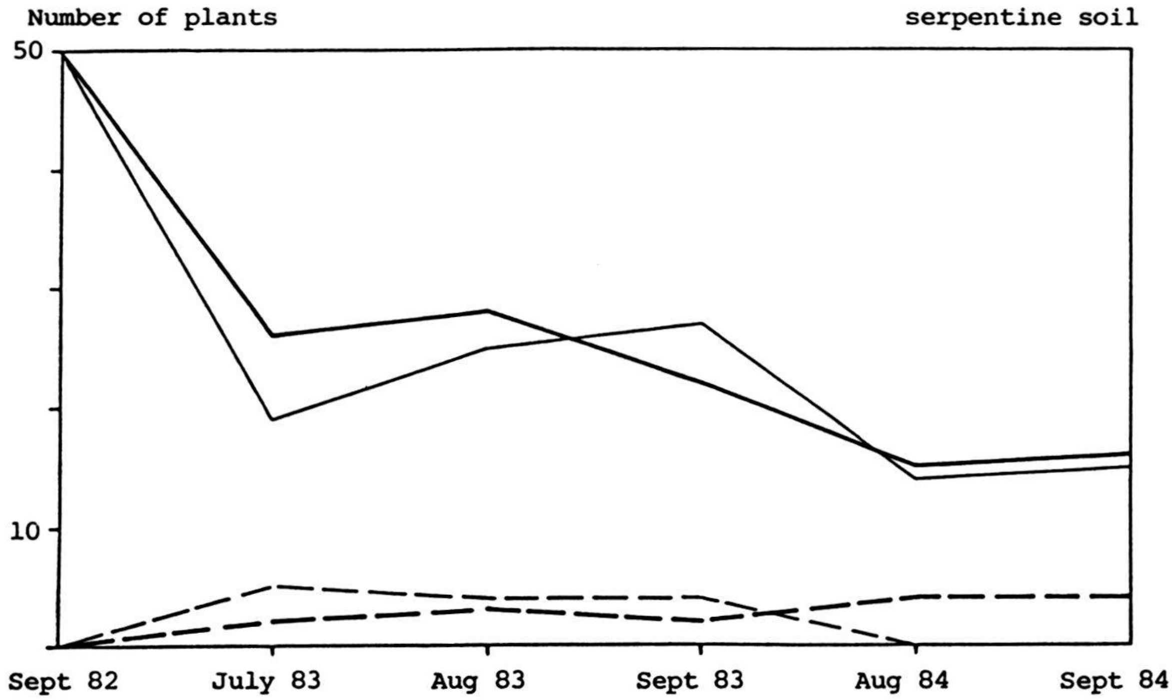
Scored on	DOL/DOL			SER/SER		
	N	h	d	N	h	d
6 July 83	2	5	10	2	5	8
8 Aug 83	4	5	10	4	5	8
7 Sept 83	4	7	13	4	7	15
6 Oct 83	6	10	15	4	10	15
25 July 84	6	12	15	6	15	15
1 Sept 84	7	25	15	6	30	15

The statistical treatment of the data revealed that germination in the field was significantly dependent on the substratum ($P < .01$) and not on the origin of the seeds, whereas the mortality was significantly influenced by both substratum and origin ($P < .01$).
Accumulation of the biomass at early life phases was assessed by the number of leaves, height, and diameter of the rosettes of the best developed plants within each series.
In the first season, there were only few differences between all series, plants grown on developed dolomite soil from seeds originating from dolomite being best developed. In the second season, the development of plants growing on foreign substratum was clearly slower; on the other hand, no distinct differences were observed between plants growing on developed soil and on scree. In the third and fourth season, the advantages of plants growing on the substratum of their origin became more and more evident (Tables 14, 15); a single four-year-old plant originating from a seed from serpentine and growing on developed serpentine soil even flowered.

3.2.3. Transplantations in the field

The success of transplanted rosettes was determined by their vitality. Green rosettes, reproducing rosettes, and plants surviving the transplantation though not necessarily having green rosettes were noted during each census.
The percentage of individuals surviving the transplantations on dolomite soil was generally low. Distinct differences were observed between plants from various sectors within a given substratum (Table 16). The percentages of survivors were clearly higher on serpentine, where plants originating from dolomite performed better than the controls. The differences between material originating from the same substratum were negligible. The generally lower percentages of survivors on dolomite might be explained by the much higher density of vegetation.
In transplantations on dolomite, the number of green rosettes decreased from census to census, without regard to the origin of transplanted material. A few rosettes were reproducing in 1983, but in 1984 no reproducing plants were observed (Fig. 29).





Figs 29,30. Transplantations: Number of plants with green rosettes (solid line) and number of plants with reproducing rosettes (dashed line) on dolomite and serpentine soil (50 plants per series.

Abb. 29,30. Verpflanzungen: Anzahl Pflanzen mit grünen Rosetten und Anzahl Pflanzen mit Blütenständen.

Plants from dolomite: ━━━━, ━ ━, Plants from serpentine: ────, ─ ─

Table 16. Transplantations: Establishment (%) (25 plants per series).
Tab. 16. Verpflanzungen: Etablierung.

DOL = dolomite, SER = serpentine.

Substratum	Origin of plants			
	DOL 7	DOL 8	SER 2,4,5	SER 3,7
Dolomite	38		42	
	48	28	32	52
Serpentine	76		60	
	80	72	56	64

The behaviour of transplanted individuals on serpentine was rather erratic e.g. some plants found dormant during the first census had green leaves in a later census. Reproducing plants were more frequent on serpentine than on dolomite; also in this respect individuals from dolomite performed better than serpentine plants (Fig. 30).
The transplantation experiments show that the behaviour of plants was influenced both by the substratum as well as the origin of the material.