Germinating behavoiur and growth potential in Taraxacum alpinum (2n=32) from the Swiss Alps = Keimverhalten und Wachstumsvermögen bei Taraxacum alpinum (2n=32) aus den Schweizer Alpen

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Germinating behaviour and growth potential in *Taraxacum alpinum* (2n=32) from the Swiss Alps

Keimverhalten und Wachstumsvermögen bei *Taraxacum alpinum* (2n=32) aus den Schweizer Alpen

by

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Contents

1. Introduction

Variation and evolution within the genus *Taraxacum* is largely influenced by reproductive behaviour, not only sexual reproduction but also agamospermy being well-known. The asexual reproduction by seed in *Taraxacum* follows the sequence diplospory-parthenogenesis. The diplospory is characterized by a virtually complete asyndesis with a subsequent pseudohomeotypic metaphase or the formation of restitution nucleus; both mechanisms result in the appearance of unreduced macrospores and were described as so-called *Taraxacum* type (see e.g. GUSTAFSSON 1946). Unreduced embryo-sacs may occasionally be fertilized, partly functional pollen being produced in most taxa. Hybridization between sexual and agamospermous taxa of *Taraxacum* is rather rare, but may sometimes contribute to a further diversification.

The genus *Taraxacum* is cytologically differentiated. Chromosome numbers are most frequently euploid (for detailed information on the subject, see e.g. FEDOROV 1969). Diploid taxa with 2n=16 are sexual; triploids (2n=24) may be facultatively agamospermous whereas higher polyploids are for the most part considered as obligately agamospermous. Differences in chromosome morphology reported by some authors (e.g. SÖRENSEN and GUDJONSON 1946, MALECKA 1962, 1969, RICHARDS 1972) suggest various mechanisms involved in the differentiation of the genus. Populations of *Taraxacum* frequently manifest a broad spectrum of variation influenced by modifications, mutations and occasional recombinations.

Germinating behaviour and early life phases in *Taraxacum alpinum* were first studied by the junior author (M.S.) in his Diploma Thesis dealing with numerous taxa from alpine scree slopes (SCHÜTZ 1983). Preliminary observations suggested some local differentiation in *T. alpinum*; further studies were thus undertaken. The results obtained are presented here.

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2. Origin of the material and notes on morphological variation

The material originated from two sites in the surroundings of Davos, Grisons. The colony from acidic silicate was found in W slope of Salezerhorn at about 2350 m a.s.l.; the granite scree was to some extent stabilized and the vegetation locally developed, small amounts of fine soil occurring in the uppermost layer. The population from carbonate was sampled in the summit area of Weissfluh (about 2700 m a.s.l.) upon unstabilized dolomite scree. Both populations were medium-large with individuals scattered over some distance.

Taxonomical treatment of the genus *Taraxacum* is exceedingly complex and the resulting interpretations vary from one author to another. The Swiss material makes no exception; for instance, VAN SOEST (1969) described as many as 235 species, whereas HESS et al. (1967-1972) argued that the genus *Taraxacum* is represented in Switzerland and its adjacent areas only by one species group viz. *T. officinale* s.l. and proposed to distinguish nine principal species. The classification of the Swiss authors was followed in the present study.

The material examined was rather variable. As far as leaf morphology and achene length are concerned, plants from both populations were similar and clearly represented *T. alpinum*. Also length of the achene rostrum, colour of achenes as well as size and colour of exterior bracts were very similar in plants from both substrata and suggested that they all belong to *T. alpinum*. On the other hand, the occurrence of small hooks on bracts observed in plants from dolomite did not preclude some affinity with *T. ceratophorum*; however, observations in plants grown in the greenhouse indicate that this character is rather unstable.

Acetocarmine test revealed an exceedingly high pollen sterility (90-95%). This character is considered as representative of agamospermous *Taraxaca* (see e.g. TCHERMAK-WOESS 1949, FüRNKRANZ 1966).

3. Cytological studies

Chromosome numbers in *Taraxacum* from high altitude sites in the Alps were only seldom studied to date. The material examined by RICHARDS (1972) was mostly collected between 1900-2000 m a.s.l.; according to LANDOLT (1983), this altitude bracket corresponds to subalpine or continental mountain zone. Only a single station studied by RICHARDS from Austria was situated at 2450 m a.s.l. and can therefore be considered as alpine. NIJS and STERK (1980) sampled four populations within alpine zone in the Swiss Alps but have not actually studied chromosome numbers, their evaluations of the ploidy level being exclusively based upon pollen morphology.

Only polyploid chromosome numbers were previously found in *T. alpinum*. Reports on Alpine triploids (2n=24) and tetraploids (2n=32) refer mostly to materials from Austria (MATTICK and TISCHLER 1950, FüRNKRANZ 1960, RICHARDS 1972). In the Tatra Mts, MAŁECKA (1962) found not only triploids and tetraploids but also pentaploids (2n=40). Cytological studies in *T. alpinum* were not carried out so far in the material from high altitudes within alpine or subnivale zone (for nomenclature and criteria in classification of altitude zones, see LANDOLT 1983).

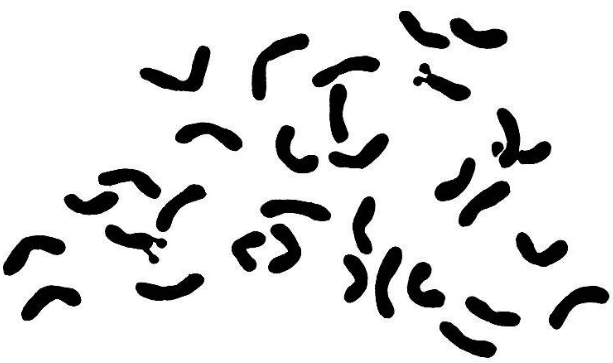

Fig. 1. *Taraxacum alpinum*: Switzerland, Grisons, summit area of Weissfluh. Dolomite scree about 2700 m a.s.l. 2n=32. c.3100x.

Taraxacum alpinum: Schweiz, Graubünden, Gipfelgebiet der Weissfluh. Dolomitschutt, ca. 2700 m ü.M. 2n=32. c.3100x.

Our cytological studies in *T. alpinum* were carried out in not pretreated root-tip meristems of seedlings. Squashes were stained with lacto-propionic orcein. The material from both sites proved to be invariably tetraploid with 2n=4x=32 (Fig. 1). The present results corroborate thus partly the previous reports. It should be desirable to study other populations from high altitudes.

4. Germinating behaviour

Germinating behaviour in alpine populations of *Taraxacum* is not well-known. To the best knowledge of the authors, the only previous data on Swiss material are those of BRAUN (1913) who studied a seed sample from Piz Forum harvested at 2610 m a.s.l. upon orthogneiss. BRAUN assigned his material to *T. officinale* and considered it as a representative component of the pioneer vegetation occurring within the nivale zone of Rhaetian-Lepontine Alps. He reported a high germination percentage viz. 78% in not pretreated seeds but, unfortunately, neither described the actual course of germination nor specified the length of the observation period.

The present studies on germinating behaviour of *T. alpinum* were carried out under controlled laboratory conditions, in the greenhouse as well as in the field. Detailed field results are not included in the present report; they are considered as too fragmentary, because the trial surface upon acidic silicate at Vorder Latschüel (2450 m a.s.l.) was greatly deformed by water erosion after the snowmelt and the seeds sown were partly washed out.

All germination trials were carried out with not pretreated seeds. Each series was studied during 100 days.

Trials in the laboratory comprised two series. The seeds studied in the first series were three-month-old. The second series was run one year later; in the meantime, seeds were dry-stored at 4°C. Seeds used in laboratory trials were sown onto moist blotting paper and kept in Petri dishes.

Differences between the material from acidic silicate and that from carbonate observed in the first series were particularly pronounced in the first half of the trial (Fig. 2). By 10th day, seeds from silicate germinated in 24% but those from carbonate were still largely dormant (germination of 4%). By 20th day, germinated seeds from silicate already represented 66% of the material whereas 40% were observed in the sample from carbonate; the difference of 26 per cent was maintained ten days later. After 30th day, germination in seeds from silicate apparently slowed down but a rather good progress was noted in seeds from carbonate;

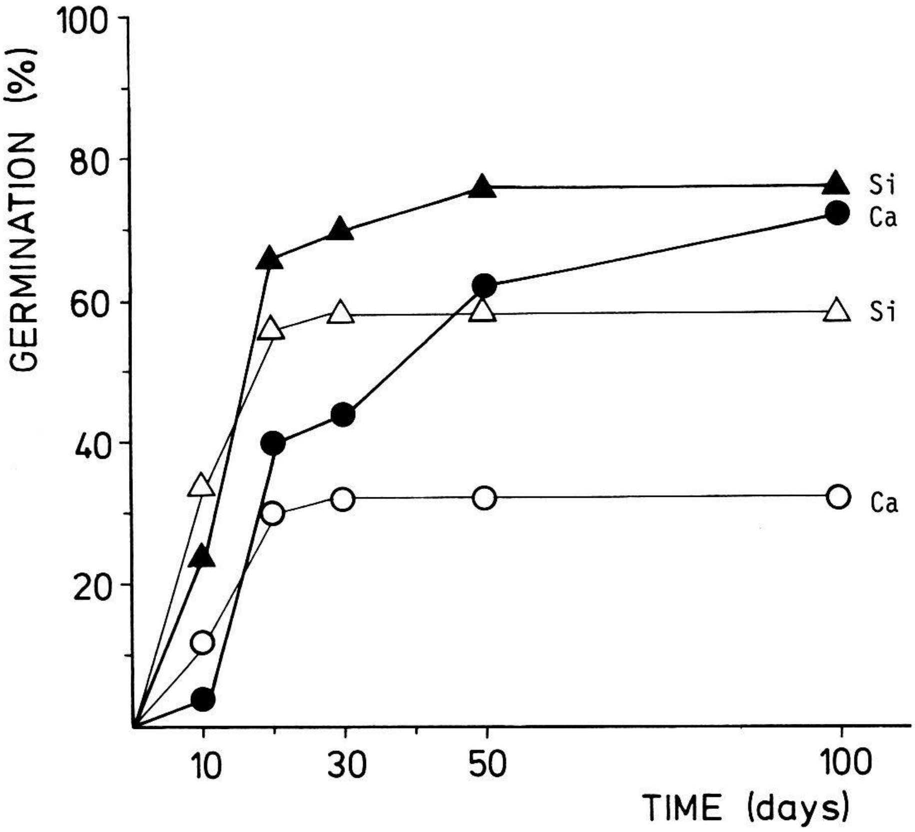

Fig. 2. *Taraxacum alpinum*: differences in germinating behaviour of seeds from acidic silicate (Si) and carbonate (Ca)

Taraxacum alpinum: Unterschiedliches Keimverhalten bei Samen von saurem Silikat- (Si) und Karbonatgestein (Ca)

▲ three-month-old seeds
● *drei Monate alte Samen*
△ fifteen-month-old seeds. Laboratory trials
○ *fünfzehn Monate alte Samen. Laborversuche*

by 50th day, difference between samples was less pronounced (76% vs. 62%). At the end of the trial, germination in the sample from silicate was slightly better than in the material from carbonate (76% vs. 72%).

Germination course in fifteen-month-old seeds was generally similar in samples from both substrata, most seeds germinating in first twenty days (Fig. 2). However, germination in the material from silicate was much better, the difference of 26 per cent noted by 20th day of the trial being maintained until the end of the observation period. At the end of the trial, germinated seeds represented 58% of the material from silicate but only 32% in the sample from carbonate.

Germination trials in the greenhouse were carried out with three-month-old seeds sown in trays filled with sterilized garden soil. Germination was generally poorer than in Petri dishes, but differences between samples were very distinct, seeds from silicate germinating faster and better than those from carbonate (Fig. 3). The trend observed in the greenhouse was thus consistent with patterns revealed in laboratory trials.

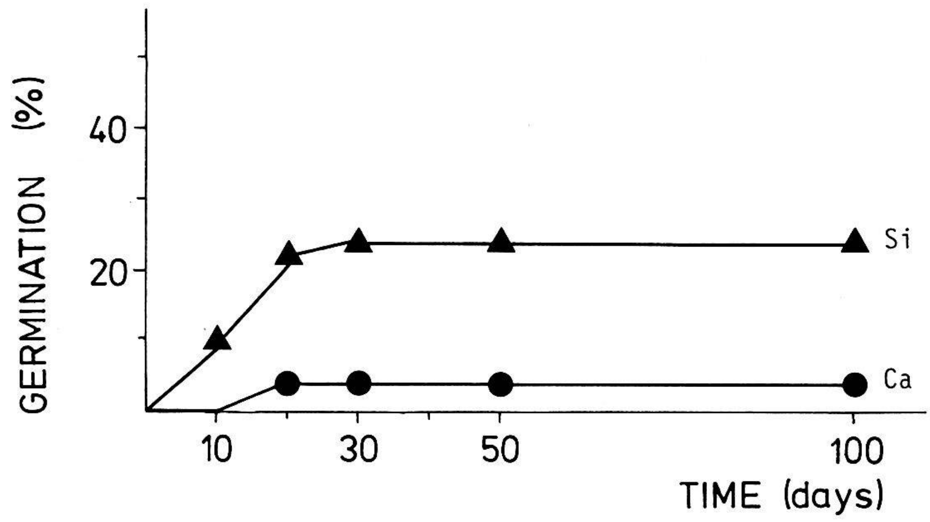

Fig. 3. *Taraxacum alpinum*: germinating behaviour of seeds from acidic silicate (Si) and carbonate (Ca) sown into garden soil. Greenhouse trials.

Taraxacum alpinum: Keimverhalten bei Samen von saurem Silikat- (Si) und Karbonatgestein (Ca) in Gartenerde ausgesät. Gewächshausversuche.

5. Development of young plants in competition-free conditions

To assess the growth potential in *Taraxacum alpinum*, single seedlings were planted in pots filled with sterilized garden soil; the development of young plants in the greenhouse was subsequently surveyed over a 100 day-period. By 10th day, only some root development was noted in seedlings from both substrata. By 25th day, young plants developed 5-7 leaves per rosette, both rosette and root system being stronger in individuals from silicate (Fig. 4). By 50th day, rosettes in plants from carbonate consisted of 7-8 large leaves, but no increase in size or number of leaves was noted in individuals from silicate. Also root system was better developed in plants from carbonate (Fig. 4). By the last day of the trial, young plants from both substrata accumulated a rather large biomass. The leaf size was generally comparable in all the individuals studied. The rosettes in plants from carbonate consisted of 14-16 leaves, those from silicate being smaller (11-12 leaves). Plants from silicate usually had fewer but stronger roots than individuals from carbonate (Fig. 4).

6. Discussion

The results obtained in the course of the present study suggest that germinating behaviour and early developmental stages in *Taraxacum alpinum* from extreme environments partly reflect adaptations to various alpine substrata.

Some authors (e.g. ZOLLITSCH 1927, ELLENBERG 1957) argued that the substratum has no influence upon germinating behaviour of seeds. General data seem to corroborate this opinion, no single universally applicable germination pattern being found in various species within a given substratum (e.g. FOSSATI 1976, 1980, ZUUR-ISLER 1982). However, recent studies in taxa occurring at high altitudes *both* upon acidic silicate and carbonate do suggest that adaptive strategies of populations within either substratum may involve the germination phase. For example, a better

Fig. 4. *Taraxacum alpinum* in the greenhouse: development of young plants from acidic silicate (Si) and carbonate (Ca) in garden soil

Taraxacum alpinum im Gewächshaus: Entwicklung der Jungpflanzen von Silikat- (Si) und Karbonatgestein (Ca) auf Gartenerde germination in seeds from carbonate than in those from acidic silicate was found in *Lotus alpinus* (URBANSKA et al. 1979) and *Silene acaulis* (WEILENMANN 1980, 1981). On the other hand, seeds of *Hutchinsia alpina*, *Oxytropis campestris* and *Cirsium spinosissimum* from acidic silicate germinated better than those from carbonate (SCHÜTZ 1983). In *Myosotis alpestris*, seeds from acidic silicate and those from carbonate germinated both in 68% but germination was faster in the latter sample (WEILENMANN 1980). Germination in *Taraxacum alpinum* from acidic silicate was consistently faster and better than in the material from carbonate, not only under various trial conditions, but also in seeds of various age; it seems therefore that the germinating behaviour might form part of the genetic make-up in this taxon. The very ionic composition of the substratum obviously represents only one niche aspect, physical soil properties as well as microclimate being of equal importance. Further studies are indispensable for a better understanding of possible adaptive components in germinating behaviour of populations inhabiting various alpine substrata.

The present study shows as well that germinating behaviour alone does not represent the deciding element in an eventual success of population and cannot be considered separately from subsequent life phases. In *Taraxacum alpinum* from acidic silicate, seeds germinated rapidly and well but accumulation of aerial biomass in young plants was slow, an opposite tendency being observed in the material from carbonate. It should also be mentioned that only seedlings upon carbonate partly survived an exceptionally unfavourable alpine summer whereas those upon acidic silicate were wiped out completely (SCHÜTZ 1983). Patterns observed in *Taraxacum alpinum* resemble those in *Geum montanum*, where a better germination upon carbonate was accompanied by much higher seedling mortality, inverse tendency occurring upon acidic silicate (FOSSATI 1980). Contrasting behaviour in consecutive life phases suggests that conditions favourable to germination are not necessary beneficial for seedling growth or survival; our results support thus the opinion of SARUKHAN (1980) that the actual ideas about "typical" r- and K-strategies should be reconsidered.

The present results suggest racial differentiation on homoploid level in *Taraxacum alpinum* from high altitude sites. Formation of local races is influenced by small neighbourhood size and selective pressures (WRIGHT 1943, 1949, GRANT 1981). Local racial differentiation is usually associated with sexual reproduction (see e.g. ANTONOVICS 1971, LEVIN and KERSTER 1974, SCHAAL and LEVIN 1978, DICKENMANN 1982, GASSER 1983); it seems, however, that it may occasionally occur also in asexually reproducing plants. As far as *Taraxacum alpinum* is concerned, chromosome number and high pollen sterility suggest that the populations studied are fully agamospermous i.e. have zero neighbourhood size. Ecologically extreme scree slopes at high altitudes clearly are subject to very strong selection. It is conceivable that conditions occurring in various alpine substrata might have promoted biotypes with different adaptive traits. Agamospermy might have been very advantageous for the subsequent development of populations in their harsh and unpredictable environments, asexually produced seeds assuring, on the one hand, a good survival and dispersal and, on the other hand, a maximum genetic stability.

Observations of SUKATCHEV (1928), NILSSON (1947), KAPPERT (1954) as well as the elegant study of SOLBRIG and SIMPSON (1974, 1977) demonstrate that genetic polymorphism occurs in some agamospermous populations of *Taraxacum*. The present results, albeit preliminary, represent a further contribution to a better comprehension of microevolution in asexually reproducing plants. It should be most interesting to investigate further populations of *Taraxacum alpinum*. The study is in progress.

Summary

Differences in germinating behaviour and early development of young plants suggest a racial differentiation in *Taraxacum alpinum* (2n=32) from high altitude sites upon acidic silicate and dolomite. It is supposed that the microdifferentiation may be influenced by the substratum.

Tetraploid *T. alpinum* is agamospermous; in view of the asexual reproduction, a possible racial differentiation on homoploid level is of a special interest.

Zusammenfassung

Unterschiede im Keimverhalten und in der frühen Entwicklungsphase von *Taraxacum alpinum* (2n=32) aus der alpinen Stufe von saurem Silikat- und Karbonatgestein lassen auf eine Rassendifferenzierung schliessen. Vermutlich wird die Mikrodifferenzierung vom Substrat beeinflusst.

Das tetraploide *T. alpinum* pflanzt sich asexuell durch Agamospermie fort. Eine mögliche Rassendifferenzierung auf homoploider Ebene ist deshalb von besonderem Interesse.

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