On the ecology of varieties of Sonchus arvensis L.

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SUMMARY

The perennial sowthistle (Sonchus arvensis L.) – a geophytic composite – is found throughout the temperature regions of the world. From the middle of the 19th century dispersal has occurred from the original area of distribution in Europe and Western Asia.

In The Netherlands two varieties can be distinguished. Both show distinct distribution patterns. The coastal type, var.*maritimus* G. F. W. Mey., has relatively narrow, long and irregularly indented, prickly leaves with a waxy surface. This variety occurs predominantly on the outer coastal dunes.
Leaves of the arable type, var. *arvensis*, are mesophytic in appearance. They are shorter and broader than those of the coastal type. The arable type may be found in a number of different habitats, always on fertile soils and principally on arable land. The two varieties have the same chromosome number, 2n=54.
Proof that the leaf morphological differences between the two varieties are genetically determined is provided by the fact that these remain unchanged when they are grown from achenes under identical conditions.

This study aims to find out by what mean(s) the varieties are adapted to their particular habitats and to trace the mechanisms responsible for their distribution patterns.

Previous literature indicates that coastal sand dunes are chemically less fertile than arable land. Chemical analysis of outer dune soil of the West Frisian Island of Schiermonnikoog confirms that nitrogen and plant available phosphate levels are low. The question thus arises as to whether and by what mean the inadequate N- and P- supplies of the dunes is responsible for the presence of the coastal, and the absence of the arable type.

Achenes of both varieties sown in the outer dune area of Schiermonnikoog germi-

nate successfully. However, eventually all seedlings of the arable type die and only a fraction of the coastal type seedlings survive. These survivals show a slow rate of growth. Persisting coastal type plants grow from relatively large and heavy achenes. Development to flowering takes about 3 to 4 years. Desiccation appears to be the ultimate cause of seedling death.

Seedlings of the arable type raised under favourable conditions fail to establish themselves when planted on the dune site of Schiermonnikoog. On the other hand many of the individuals of the coastal type develop into flowering and achene bearing plants. Dressings of superphosphate show no effects on the growth of either the coastal or the arable type. Application of nitrogenous fertilizer make no difference to the growth of the arable type. When administered to the coastal type, growth improves considerably and development was noticeably accelerated. Combined dressings of N- and P-fertilizers result in greatly stimulated growth and development of both types to such an extent that their life-cycle can be completed during the year of planting.

When grown on balanced nutrient solutions well supplied with minerals the dry matter production per unit time proves to be larger for the arable type than for the coastal type. This higher rate growth of the arable type is largely explained by the storage of total water soluble carbohydrates in thickened roots. The total dry weight of structural material, i.e. the dry matter of both roots and shoots minus the water soluble carbohydrates, is also higher in the arable than in the coastal type.
The coastal type produces relatively few thickened roots. The ratio shoot: total root dry weight is lower in the arable type than in the coastal type. The opposite holds for the ratio shoot: thin root dry weight. The ability to generate an extensive fibrous root system appears to be one reason why the coastal type can survive on N- and P-deficient dune sand.

Chemical analysis demonstrates the thickened roots of the arable type to be outstanding in their relatively high content of organic nitrogen and possibly organic phosphate as well. Varietal differences in mineral contents of other plant parts have not been ascertained.
The higher Norg. and possibly Porg. contents mentioned, allied to a larger dry matter production of the arable type, is indicative of the comparatively high nutrient demands of this variety.
On non-fertilized coastal dune sands these demands cannot be met by the spatially restricted root system of this type. The limited nutrient supplies of the dune sand can be exploited more efficiently by the root system of the coastal type, but even for this variety the N-supplies are inadequate for optimal growth and development.

Seedlings of neither variety have been found on arable land. Despite this, sowing of both varieties at the inland experimental garden of Haren show good germination. This indicates that establishment from achenes is possible. If left undisturbed seedlings grow well and develop into vigorous plants that flower and bear achenes in the second year after sowing due to the relatively late date of sowing.
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Both varieties can be propagated vegetatively from pieces of thickened root. Propagation from similar sized root fragments of the two types carried out in spring results in a much more vigorous shoot growth in the arable type. This is probably due to the larger amounts of total water soluble carbohydrates found in the thickened roots of the arable type. Per unit weight of stored total water soluble carbohydrates, the shoot dry weight of plants regenerated from root buds is the same for both types. The rate of sprouting is lower in the autumn than in the spring. The seasonal differences are more pronounced for the arable type than for the coastal type. The number of buds per unit length of thickened roots shows neither varietal differences nor differences depending on season.

Following mechanical defoliation in spring and summer of previously established plants regrowth of the arable type is more vigorous than of the coastal one. This also is thought to be due to the differences in total amounts of stored water soluble carbohydrates in the two varieties. After mid-summer regrowth after defoliation is no longer possible at the prevailing temperatures.

The above results illustrate the relatively low capacity of the coastal type to overcome mechanical disturbances such as would occur on agricultural land. Furthermore, previously established coastal type plants disappear completely after being grown among agricultural crops for three years. Neither the density and surface coverage of the crop plant, nor the species grown (e.g. oats or potatoes) are the significant factors. The arable type is not eradicated by the agricultural operations, but its growth is diminished by the competing crop.

Differences in the distribution patterns of the two varieties must have originated in habitat-adapted selection. In the coastal sand dunes selection for:

(i) the extensive root system that is capable of exploiting the soil nitrogen and plant available phosphate supply most effectively;
(ii) the relatively low nitrogen demand;
(iii) the rate of growth and development keeping pace with the nitrogen supply;

(iv) the comparatively small restriction in the rate of shoot growth from root buds in early spring.

On arable land and on fertile sites selection for:

(i) the rate of dry matter production that is efficient enough to compete with that of (cultivated) plants;

(ii) the more frequent formation of thickened roots with a relatively high content of non-structural carbohydrates;

(iii) the substantial limitation during low spring temperatures of the rate at which shoots grow from root buds; thus preventing premature sprouting as a safe-guard against adverse growing conditions;

(iv) the ease with which, in spring and summer, regeneration from fragments of thickened roots takes place and defoliated plants develop new shoots.

Cross-pollination between the types might result in hybrid populations that cannot be distinguished on the basis of leaf morphology from populations of the arable type. These hybrids are also likely to resemble the arable type physiologically. There is no evidence to prove whether or not uncontrolled hybridization occurs.