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# LIPID CONTENT AND FATTY ACID COMPOSITION OF SEEDS OF *CAPSELLA* SPECIES FROM DIFFERENT GEOGRAPHICAL LOCATIONS

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**Key Word Index**—*Capsella bursa-pastoris*, *C rubella*, *C grandiflora*, Cruciferae, effect of geographical location, fatty acid composition, lipid content

**Abstract**—Seeds of natural populations of *Capsella bursa-pastoris*, collected from temperate regions, weighed less and had a higher lipid content than those from colder regions The long-chain (16 0, 18 0, 18 1, 18 2 and 18 3) and very long-chain (20 0, 20 1, 20 2 and 20 3) fatty acid compositions were, however, quite similar in the lipids of all the seed samples which indicates a rigid genetic, rather than environmental, control of fatty acid biosynthesis Characteristics of the seeds of the diploid species *C rubella* and *C grandiflora* were similar to those of the tetraploid *C bursa-pastoris*, with the exception of the distinctly lower lipid content in *C grandiflora* seeds

## INTRODUCTION

The weight of a seed broadly reflects its energy content which is available for germination In most seeds, lipids, mainly triacylglycerols, constitute the major source of energy [1] Seed weight and lipid content of the seed may vary within a plant species, depending on geographical location and environmental factors In several instances, seeds from warm regions are reported to weigh less and to have a lower lipid content than those from colder regions [2–5] However, in many plant species both seed parameters seem to be independent variables [2, 4] Environmental factors, such as temperature and light, may also affect the composition of constituent fatty acids of seed lipids Thus, low temperature generally seems to favour the accumulation of polyunsaturated fatty acids [4–9], although individual plant species may respond differently to such environmental factors [6, 9]

We report here the variability of seed weight and lipid content as well as the fatty acid composition of the seeds of natural populations of three *Capsella* species which were collected from widely different geographical locations One of these species, *C bursa-pastoris*, is particularly suitable for evolutionary studies, because it is one of the most widespread plants on earth and grows under extremely different climatic conditions [10]

## RESULTS AND DISCUSSION

Seeds from natural populations of *C bursa-pastoris* (L) Med (tetraploid), *C rubella* Reuter and *C grandiflora* (Fauche & Chaub) Boiss (both diploid) were collected from widely different geographical locations ranging from Afghanistan to Scotland and Italy to Finland at altitudes ranging from sea level to over 2000 m The average weights of the seeds and their lipid contents are given in Table 1 The fatty acid compositions to the seed lipids, which consisted almost exclusively of triacylglycerols, are given in Table 2

As general characteristics of the *Capsella* seeds, with the exception of *C grandiflora*, an average lipid content of *ca* 30% was found (Table 1) The seed lipids of all the *Capsella* species contained, in addition to the common plant fatty acids, i e palmitic (16 0), stearic (18 0), oleic (18 1), linoleic (18 2) and linolenic (18 3), fairly large proportions of very long-chain fatty acids ($> C_{18}$) (Table 2) which are characteristic of Cruciferae [1] Gadoleic acid (20 1) was by far the major very long-chain fatty acid, whereas erucic acid (22 1), which is the major constituent fatty acid of many cruciferous seeds, was only a minor constituent (Table 2)

It is generally accepted that 20 1 and 22 1 acids are formed by chain elongation of oleic acid [11–14] Apparently, in *Capsella* seeds the chain elongation of oleic acid does not proceed beyond the $C_{20}$ chain Analysis of the monounsaturated fatty acids from the seeds of *C bursa-pastoris* (Table 1, sample No 1) by reductive ozonolysis and GC revealed that octadecenoic acids consisted of 86% of the 18 1(9) isomer (oleic acid) and 14% of the 18 1(7) isomer (vaccenic acid), whereas icosenoic acids consisted of 94% of the 20 1(9) isomer (gadoleic acid) and 6% of the 20 1(7) isomer These results corroborate previous findings in *Brassica napus* and *Sinapis alba* seeds, in which oleic acid, rather than vaccenic acid, was found to be preferentially elongated [14]

The occurrence in *Capsella* seeds of some very long-chain polyunsaturated fatty acids, i e icosadienoic (20 2) and icosatrienoic (20 3) acids, is noteworthy (Table 2)

The average weights and lipid contents of the seeds of *C bursa-pastoris* from different geographical locations (Table 1) show the following features In general, the plants from temperate regions (samples Nos 3, 4 and 10) yielded distinctly lighter seeds with a higher lipid content than those from colder regions (e g samples Nos 2, 6, 8 and 9) Moreover, the lipid content of the seeds was found to increase consistently with decreasing seed weight The lipid content of the seeds of *C rubella* was similar to that of *C bursa-pastoris*, but seeds of *C grandiflora* had a distinctly lower lipid content (Table 1)

Table 1 Weight and lipid content of seeds of *Capsella* species from various geographical locations

| Species (sample No) | Location: Country/region | Latitude/longitude (°N) (°E) | Altitude (m) | Seed wt (mg/1000 dry seeds) | Lipid content (% dry wt) |
|---|---|---|---|---|---|
| *C bursa-pastoris* | | | | | |
| (1) | Switzerland/Grindelwald | 46 38/8 00 | 660 | 121 1 | 34 4 |
| (2) | Afghanistan/Hindukush | 36 10/71 20 | 2400 | 141 6 | 30 1 |
| (3) | Germany/Bodensee | 47 42/9 05 | 400 | 93 4 | 33 4 |
| (4) | Germany/Emsland | 52 38/7 22 | 75 | 98 5 | 39 7 |
| (5) | Sweden/Trelleborg | 55 25/13 00 | 20 | 126 3 | 31 3 |
| (6) | Finland/Kevo | 69 45/27 00 | 160 | 151 2 | 27 4 |
| (7) | Sweden/Bornholm | 55 17/14 46 | 10 | 127 1 | 29 6 |
| (8) | Switzerland/Julierpass | 46 28/9 48 | 2200 | 155 5 | 27 8 |
| (9) | Switzerland/Furkapass | 46 34/8 25 | 2140 | 137 7 | 29 4 |
| (10) | Netherlands/Zandfoort | 52 25/4 34 | 10 | 107 4 | 31 2 |
| (11) | Scotland/Achnasheen | 57 35/5 05 (°W) | 900 | 115 8 | 36 2 |
| *C rubella* | Italy/Campamenosa | 39 50/16 05 | 960 | 129 9 | 32 4 |
| *C grandiflora* | Greece/Corfu | 39 43/19 50 | 370 | 101 1 | 19 6 |

Table 2 Fatty acid composition of total lipids in seeds of *Capsella* species from various geographical locations

| Species* (sample No) | Fatty acid (wt %) 16 0 | 16 1 | 18 0 | 18 1 | 18 2 | 18 3 | 20 0 | 20 1 | 20 2 | 20 3 | 22 1 | Others† |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C bursa-pastoris* | | | | | | | | | | | | |
| (1) | 8 2 | 0 4 | 4 8 | 13 5 | 21 5 | 33 5 | 1 4 | 12 5 | 1 9 | 1 1 | 0 4 | 0 6 |
| (2) | 9 7 | 0 8 | 3 3 | 22 7 | 22 4 | 26 8 | 0 7 | 11 4 | 0 9 | 0 7 | 0 3 | 0 2 |
| (3) | 7 5 | 0 4 | 6 1 | 17 4 | 23 8 | 26 8 | 2 1 | 12 6 | 1 5 | 0 9 | 0 4 | 0 4 |
| (4) | 9 5 | 0 4 | 5 7 | 19 4 | 23 8 | 25 5 | 1 2 | 11 6 | 1 5 | 0 9 | 0 3 | 0 2 |
| (5) | 9 1 | 0 4 | 4 8 | 13 7 | 21 4 | 35 0 | 1 3 | 10 6 | 1 8 | 1 2 | 0 3 | 0 4 |
| (6) | 7 3 | 0 3 | 3 9 | 17 1 | 23 5 | 32 5 | 1 3 | 11 5 | 0 9 | 1 0 | 0 5 | 0 3 |
| (7) | 8 5 | 0 4 | 4 5 | 13 1 | 22 4 | 33 7 | 1 5 | 12 2 | 1 9 | 1 1 | 0 4 | 0 3 |
| (8) | 7 1 | 0 4 | 4 2 | 18 6 | 30 0 | 23 6 | 1 6 | 11 3 | 1 3 | 0 8 | 0 5 | 0 7 |
| (9) | 8 6 | 0 5 | 4 7 | 13 6 | 25 7 | 32 4 | 1 0 | 10 4 | 1 9 | 0 9 | 0 2 | 0 2 |
| (10) | 7 9 | 0 3 | 5 3 | 14 8 | 22 0 | 31 4 | 2 1 | 12 6 | 1 7 | 1 1 | 0 4 | 0 3 |
| (11) | 7 8 | 0 3 | 4 9 | 10 9 | 20 0 | 38 2 | 1 8 | 12 3 | 1 9 | 1 3 | 0 3 | 0 2 |
| *C rubella* | 7 8 | 0 4 | 4 6 | 13 4 | 20 0 | 30 0 | 2 1 | 17 8 | 2 3 | 1 0 | 0 5 | 0 1 |
| *C grandiflora* | 8 9 | 0 6 | 5 4 | 18 1 | 23 1 | 21 4 | 2 2 | 16 3 | 2 1 | 0 9 | 0 7 | 0 3 |

*Geographical locations as given in Table 1
†Including 22 0, 24 0 and 24 1

The fatty acid compositions of the seed lipids from various samples of *C bursa-pastoris* were strikingly similar (Table 2) Only in a few instances were diverging values observed for 18 1 (10 9% in sample No 11 vs 22 7% in sample No 2), 18 2 (30 0% in sample No 8 vs *ca* 22% in other samples) and 18 3 (38 2% in sample No 11 vs 23 6% in sample No 8) Despite these variations, the total amount of polyunsaturated fatty acids was fairly constant (50–60%) in all samples of *C bursa-pastoris* All these findings indicate that in this particular plant species fatty acid biosynthesis in the seeds is under rigid genetic, rather than environmental, control, as has been observed in some other plants [6, 9]

The seed lipids of *C rubella* and *C grandiflora* had slightly higher levels of 20 1 compared to *C bursa-pastoris* (Table 2) Otherwise, the fatty acid compositions of the seeds from the three *Capsella* species were quite similar except for a somewhat lower level of polyunsaturated fatty acids in *C grandiflora*

The closer resemblance of the tetraploid *C bursa-pastoris* seeds to those of the diploid *C rubella*, rather than *C grandiflora* with respect to lipid content and fatty acid composition could suggest that *C rubella* was a likely parent of *C bursa-pastoris*

## EXPERIMENTAL

Seeds from natural populations of *C bursa-pastoris*, *C rubella* and *C grandiflora* were collected during excursions Lipid extraction, TLC of total lipids, preparation and purification of methyl esters by TLC and prep GC, reductive ozonolysis and GC analyses were carried out according to methods described previously [14]

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