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LIPID CONTENT IN LEAVES OF *DESCHAMPSIA ANTARCTICA* FROM THE MARITIME ANTARCTIC

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Key Word Index—*Deschampsia antarctica*; Gramineae; cold stress; fatty acids; freezing tolerance; polar lipids.

Abstract—*Deschampsia antarctica* plants were collected in Robert Island, Maritime Antarctica, and frozen in liquid nitrogen. Polar lipids and the composition of fatty acids in phospholipids and galactolipids were analysed in leaves and roots. Compared to other Gramineae, no unusual contents in polar lipids and in the degree of unsaturation of fatty acids in most lipid fractions were found. The highest unsaturation ratio (unsaturated/saturated fatty acids) of 3.3 was found in the phosphatidylinositol fraction. Although summer environmental temperatures in Robert Island are usually around 0°, leaves often reach higher temperatures, which are near their photosynthetic optimum.

INTRODUCTION

Deschampsia antarctica Desv. is one of the two vascular plants that have colonized the Maritime Antarctic [1, 2]. Maximum temperatures in this area usually range between 0° and 6° in January (summer), while the minima range between 0° and −6°. The daily mean during the growing season is often 0° [3]. It has been suggested that *D. antarctica* may cope with low air temperature by occupying the most favourable habitats and that it has not developed any unique metabolic adaptations for survival under Antarctic conditions because its growth habit permits the leaves to operate several degrees higher than ambient temperature [3]. Low temperatures enhance lipid accumulation in some plants. Phospho- and galactolipid contents, as well as unsaturated fatty acids, are augmented in plants from cold regions [4, 5]. Dorne *et al.* [6] reported that in some Alpine plants polar lipid contents and unsaturated fatty acids were not increased by low temperature.

To operate under relatively low temperature, plant membranes must be sufficiently fluid to allow metabolic reactions [4, 7]. Membrane fluidity is partially determined by fatty acid composition and unsaturation in different lipid fractions and it may play a role in cryoprotection of plants [8]. In this paper, we report on the polar lipid composition of roots and leaves of *D. antarctica* under field conditions in Robert Island, Maritime Antarctic.

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RESULTS AND DISCUSSION

Polar lipids

The content of individual polar lipids in leaves and roots from field-collected plants was determined (Fig. 1). Galactolipids were higher in leaves than in roots, while phospholipids were similar in roots and leaves, with the

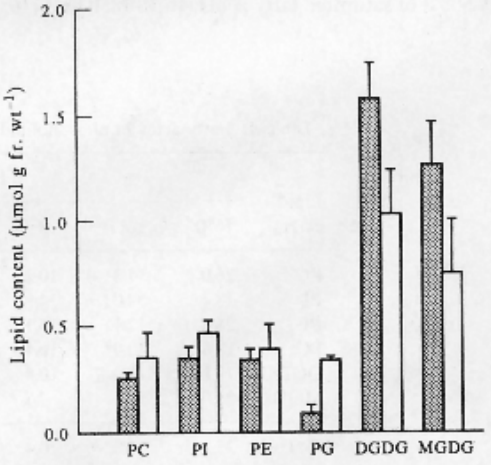

Fig. 1. Polar lipid contents of leaves and roots of *D. antarctica*. PC = phosphatidylcholine, PI = phosphatidylinositol, PE = phosphatidylethanolamine, PG = phosphatidylglycerol, DGDG = digalactosyldiacylglycerols and MGDG = monogalactosylacylglycerols. Dark bars = leaves; clear bars = roots.

exception of PG. Increased proportions of PG in roots than in leaves were found in the microsomal fraction of *Vicia faba* [9]. Thus, different cell organelles seem to have different lipid compositions and the content of whole organs may reflect the composition of individual organelles. Tevini and Lichtenthaler [9] have indicated that in membranes of non-green organelles from some plants there is a striking uniformity in phospholipid composition. Since chloroplast membranes contain higher proportions of galactolipids than phospholipids, it was expected that galactolipids would be higher in leaves than in roots and phospholipids higher in roots [9]. Galactolipid contents were higher in *D. antarctica* leaves than in leaves of cold acclimated *Avena* [10], but much lower than in barley leaves [11]. Barley is able to resist lower temperatures than those in the Maritime Antarctic, but requires higher temperatures for growth and reproduction.

Fatty acids in leaves and roots

The proportion of fatty acids in polar lipid fractions was measured in leaves and roots of field-collected plants. Unsaturation ratios in leaves ranged from 0.75 in PG to 3.3 in PI (Table 1). This unsaturation was mostly due to high proportions of 18:3. Unexpectedly, the highest content of 18:3 in phospholipids was found in PI. Usually, PI corresponds to the most saturated phospholipid fraction in green tissues [12]. In non-cold-acclimated oat plants proportions of saturated fatty acids in PI were higher than those in PC and PE, but lower than in PG fractions [10]. Hexadeca-*trans*-3-enoic acid (*t*16:1) was considered to be a saturated fatty acid due to the position of the double bond in this compound [13]. Importance has been given to the fatty acid composition of PG in relation to chilling sensitivity of plants [13, 14]. According to Roughan [13], plants with high proportions (50–60%) of saturated fatty acids (16:0, 18:0 and *t*16:1) in the PG fraction are sensitive to chilling. Similar proportions of saturated fatty acids (57%) were found in *D. antarctica*. This suggests that this species is chilling-sensitive. However, the low content of PG and the high unsaturation of fatty acids of other lipid fractions (PI and MGDG) may confer efficient cold protection to this species. By genetic manipulation of the fatty acid unsaturation in the PG fraction the chilling sensitivity of some plants can be improved [14].

Polar lipids containing higher proportions of unsaturated acids may confer low temperature resistance to some species [4]. With the exception of PE, unsaturation of phospholipids in *D. antarctica* was lower in roots than in leaves (Tables 1 and 2). The proportions of 18:3 in galactolipids of both leaves and roots were much lower than those in oat and barley [10, 11]. Since accumulation of 18:3 is stimulated by low temperature in some species [4, 15], we expected that *D. antarctica* would show higher proportions of this acid than the above mentioned cereals. Perhaps, the temperatures in the collecting sites were not low enough to enhance accumulation of this acid. It is possible, that in winter, when plants are in a hardened stage, increased proportions of this acid or other unsaturated fatty acids could be found. A relation between unsaturated fatty acid accumulation and cold acclimation has been demonstrated for other species [16, 17]. It has also been proposed that 18:3 is not a prerequisite for cold-hardening of winter wheat [17], but it is difficult to accept that increased unsaturation of fatty acids at low temperature does not have some benefit for the plant. As Alberdi *et al.* [5] pointed out, a higher proportion of unsaturated fatty acids is not consistently correlated with a higher frost-resistance in all species.

No unusual content in polar lipids, nor in the degree of unsaturation of fatty acids from these fractions was found in leaves and roots of *D. antarctica*. However, it is of interest to point out the low content of PG, a fraction associated with chilling sensitivity [14]. On the other

Table 1. Fatty acids in phospholipids and galactolipids from *D. antarctica* leaves

Lipid class	Fatty acid (mol %)						
	16:0	16:1	18:0	18:1	18:2	18:3	UR
PC	26.0	17.3	10.2	13.4	13.0	20.0	1.76
PI	18.4	34.0	4.9	10.7	10.6	21.5	3.30
PE	28.5	12.1	16.1	16.7	11.2	15.2	1.20
PG	28.6	18.0*	10.4	12.1	11.8	19.0	0.76
DGDG	27.8	18.0	10.4	13.0	12.1	20.1	1.78
MGDG	24.0	12.4	7.7	10.2	13.7	31.9	2.15
% Total	25.7	18.0	10.4	13.0	12.1	20.1	1.78

*Hexadecanoic acid (*t*16:1) in this fraction was determined from its GC R_t. UR, unsaturation ratio (UR=16:1+18:1+18:2+18:3/16:0+18:0). [UR of the PG fraction was calculated considering 16:1 as saturated.]

Values correspond to the average of three samples with two replicates each. Standard errors were less than 10%. Abbreviations as in Fig. 1.

Table 2. Fatty acids in phospholipids and galactolipids from roots of *D. antarctica*

Lipid class	Fatty acid (mol %)						
	16:0	16:1	18:0	18:1	18:2	18:3	UR
PC	29.9	17.3	11.5	9.8	11.1	12.1	1.41
PI	19.6	16.0	9.2	2.6	16.2	26.3	2.27
PE	28.4	18.3	11.0	10.7	16.6	15.0	1.54
PG	32.9	15.4	13.1	4.4	19.5	14.6	0.63
DGDG	22.8	14.2	7.9	12.2	19.3	24.5	2.26
MGDG	31.4	17.7	9.6	11.0	11.6	18.7	1.44
% Total	23.1	17.9	10.4	10.2	15.8	18.6	1.71

UR, unsaturation ratio (UR = 16:1 + 18:1 + 18:2 + 18:3/16:0 + 18:0).
Abbreviations as in Fig. 1.

hand, it is possible that other mechanisms of cold-resistance could be involved in conferring the capacity to live and grow under low temperatures to this species; alternatively, the Antarctic environmental conditions may not be as harsh as previously thought. When radiation is high, this species is usually at a higher temperature than the surrounding air [3]. For instance, leaves of plants collected for lipid analyses were at 9.4°, while the ambient temperature was 2.8°. Since the optimum for CO_2 exchange in plants grown in growth chambers is *ca* 15° [3], this species can often reach optimal conditions for CO_2 assimilation in its natural habitat. Nonetheless, other possible biochemical, physiological and morphological strategies for plants to survive under a constant low temperature regime need to be studied.

EXPERIMENTAL

Sampling and collection site. Plants were collected in the Coppermine Peninsula in Robert Island, Maritime Antarctica (62°22′ S, 59°43′ W) on 21 February 1992. At collection time, temps were air 2.8° (12 cm from soil), roots 3.8° (2 cm under soil level) and leaves 9.4° (inside tussock). Samples were dipped into liquid N_2 and stored until extraction.

Lipid extraction. Samples (1 g) of leaves or roots were submerged in 10 ml isoProH at 82°. Tissue was cooled to room temp. and then extracted at 0° under N_2 using $CHCl_3$–MeOH (2:1) containing 0.01% 2,6-*bis* (1,1-dimethylethyl)-4-methylphenol (**BHT**). Complete extraction of lipids and purification of the $CHCl_3$ phases were performed following the methods described in refs [18, 19]. Phospholipids were determined according to ref. [19]. Galactolipids were estimated by determination of galactose residues following acid hydrolysis with H_2SO_4 [20]. Fatty acids were identified and quantified as Me esters by GC [21], using a FID detector. The carrier gas was N_2 at 24 ml min^{-1}. Operating conditions were, temp. prog. 140° to 220° at 4° min^{-1}, detector temp. 300° and injection temp. 250°, with an inj. vol. of 2 μl. Capillary columns of Supelcowax 10 m were used.

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