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FATTY ACID CHANGES IN *ALTHAEA ROSEA* TISSUES DURING GROWTH

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Abstract—Lipids were isolated from roots, stems, leaves, buds, flowers and seeds of *Althaea rosea* plants at different stages of growth. The lipid contents of all tissues, except the seeds, decreased with age. Cyclopropene and cyclopropane fatty acids were present in all tissues. The major fatty acids, in decreasing order were: palmitic, linoleic and linolenic in stems, buds and flowers; malvalic, palmitic, sterculic and linoleic in the roots; linolenic, palmitic and linoleic in the leaves; and linoleic, oleic and palmitic in the seeds. More malvalic than sterculic acid was present in all tissues except the stems and buds. The fatty acid composition of all tissue lipids underwent a significant change during or just prior to bud formation.

INTRODUCTION

Changes in composition of storage lipids in oilseeds during their maturation have received much attention [1, 2]. Similar studies on the changes in structural lipids of plant tissues during growth are scanty and should throw much light on their formation and function. In a previous communication [3] we reported the changes in various tissues of okra (*Hibiscus esculentus*). Seeds of this plant contained small proportions of cyclopropene (CFA) and epoxy fatty acids. It was observed that the formation of CFA in roots (the only tissue other than seeds to contain these fatty acids) coincided with the formation of buds in this plant. To confirm whether this is a general pattern of plants containing CFA another species belonging to Malvaceae, namely hollyhock (*Althaea rosea*), which also contains cyclopropene [4] and epoxy acids [5] in its seeds was investigated and the results are reported in this communication.

RESULTS AND DISCUSSION

Root lipids

The lipid content of roots decreased until flowering and thereafter remained almost constant (Table 1). The major fatty acids were malvalic (18:1 CFA), 16:0 and sterculic (19:1 CFA). *A. rosea* is probably the first plant reported to have CFA as the major fatty acids in root lipids. These acids constituted 48% of the total fatty acids in roots at the stage of full maturation of seeds. Sterculic acid content was highest during bud formation and the flowering stages, and malvalic acid content was highest during seed maturation. Total CFA content was lowest just before bud formation and highest after seed maturation. Dihydro CFA as well as 17:1 were also present in small concentrations. The 16:0 content increased continuously until bud formation and then decreased. The changes in 18:2 were not profound but the maximum content was observed just before bud formation.

Stem lipids

The lipid content of stems decreased throughout the growth period (Table 2). The major fatty acids were 16:0, 18:2 and 18:3. The 16:0 content remained fairly constant except for an increase just before bud formation and a decrease after bud formation. An increase during bud and flower formation and a substantial decrease afterwards was noted in the content of 18:1 as was noted in root lipids. The 18:2 content generally increased except for reduction after bud formation and then remained constant. The reverse change was noted with 18:3. Appreciable amounts of CFA were present in stem lipids until bud formation and again during seed maturation. It is worth noting that while the roots and seeds contained more malvalic than sterculic acid the stem lipids generally contained more sterculic than malvalic acid. The contents of these acids were lowest during bud and flower formation.

Leaf lipids

Lipid content was highest just before bud formation and reduced substantially immediately thereafter (Table 3). As observed generally with lipids of leaves, 18:3 was the predominant fatty acid. Its content decreased until bud formation and then increased to its original value and remained fairly constant thereafter. Other major acids were 16:0 and 18:2. The 16:0 content increased until bud formation and then decreased as was observed in the root lipids. Small amounts of CFA were present at all stages, the maximum being during seed maturation. The presence of CFA in the leaves of some other plants belonging to Malvaceae has been reported previously [8, 9].

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Table 1. Changes in *A. rosea* root fatty acids during plant growth

Days after sowing	Plant growth stage	Lipid (% dry wt)	Fatty acids* (wt %)											
			16:0	16:1	17:1	18:0	18:1	18:2	18:3	22:0	18:1†	19:1†	18:0‡	19:0‡
25		16.9	21.5	Tr	0.2	3.6	5.0	13.0	8.5	4.1	25.5	14.3	0.4	3.7
50		13.1	25.2	Tr	0.1	1.1	4.7	12.5	9.0	3.1	27.7	15.0	0.3	0.7
75		7.7	28.3	Tr	Tr	2.6	8.9	17.8	8.7	0.0	20.7	10.9	Tr	1.4
90	Bud formation	5.8	23.1	Tr	Tr	1.9	9.0	15.9	8.8	0.0	23.1	15.2	Tr	2.8
99	Flower formation	5.6	19.2	0.4	0.4	3.0	11.2	13.0	6.0	Tr	26.0	15.8	0.3	2.8
105	Seed maturation	3.1	19.4	Tr	0.5	2.0	2.8	14.0	8.9	5.0	34.5	11.0	0.7	1.6
140		3.8	17.1	0.0	0.9	2.3	3.7	13.2	4.3	8.4	36.1	12.2	Tr	2.0

*12:0, 14:0, 20:0 were also present at all the stages (each <0.5%).
†Cyclopropene fatty acids.
‡Cyclopropane fatty acids.
Tr, trace.

Table 2. Changes in *A. rosea* stem fatty acids during plant growth

Days after sowing	Plant growth stage	Lipids (% dry wt)	Fatty acids* (wt %)											
			16:0	16:1	17:1	18:0	18:1	18:2	18:3	22:0	18:1†	19:1†	18:0‡	19:0‡
25		15.0	29.7	Tr	0.6	3.7	8.2	19.9	27.2	Tr	1.6	6.8	Tr	1.3
50		8.1	29.7	0.0	0.3	2.2	8.5	19.6	24.7	2.5	2.2	9.3	Tr	0.2
75		8.0	33.5	Tr	0.0	2.3	12.3	26.6	21.3	0.0	2.0	0.7	Tr	0.5
90	Bud formation	4.0	29.5	Tr	0.0	1.1	13.2	29.4	24.2	0.0	1.3	Tr	Tr	0.5
99	Flower formation	4.0	27.8	0.0	0.2	4.6	14.7	26.1	24.8	Tr	Tr	Tr	0.4	0.2
105	Seed maturation	2.1	23.0	0.1	0.4	3.4	5.6	28.0	26.2	0.9	3.8	4.7	2.5	1.2
140		1.1	29.3	0.6	1.0	0.3	3.7	38.4	20.5	0.2	2.7	1.0	0.2	0.1

*12:0, 20:0 were also present (each <1.0%).
†Cyclopropene fatty acids.
‡Cyclopropane fatty acids.
Tr, trace.

Table 3. Changes in *A. rosea* leaf fatty acids during plant growth

Days after sowing	Plant growth stage	Lipid (% dry wt)	Fatty acids* (wt %)											
			14:0	16:0	16:1	17:1	18:0	18:1	18:2	18:3	18:1†	19:1†	18:0‡	19:0‡
25		11.0	0.7	20.4	Tr	0.4	1.1	4.9	14.6	56.7	0.5	0.5	Tr	0.5
50		11.0	1.3	25.3	Tr	1.4	2.4	5.1	14.4	50.2	Tr	Tr	Tr	Tr
75		13.6	0.2	29.1	Tr	0.0	1.3	6.1	16.6	46.9	Tr	Tr	Tr	Tr
90	Bud formation	7.9	0.8	21.0	Tr	0.0	1.3	5.7	13.6	56.8	Tr	0.1	Tr	0.3
99	Flower formation	6.1	0.8	18.1	0.7	0.3	1.3	3.0	16.2	59.1	Tr	Tr	Tr	Tr
105	Seed maturation	4.6	0.5	20.6	0.9	0.7	0.2	1.7	16.8	57.2	1.4	1.1	Tr	0.1
140		7.2	1.7	26.5	Tr	Tr	0.5	3.4	10.2	55.1	0.6	1.4	Tr	Tr

*12:0, 20:0 were also present (each <0.8%).
†Cyclopropene fatty acids.
‡Cyclopropane fatty acids.
Tr, trace.

Bud and flower lipids

The lipid content increased during the transformation from buds to flowers (Table 4). Buds were analysed at two stages; 4 and 8 days after they were observed on the plant. Flowering took place 10 days after bud formation. Major fatty acids were 16:0, 18:3 and 18:2. CFA and traces of their dihydro derivatives were also present. The major change in the fatty acids between the two stages of buds was an increase in the 18:3 and CFA contents with a corresponding decrease in 16:0. Lipid content of flowers was higher than that of buds at either stage. The fatty acid composition of flower lipids was somewhat similar to that of 8-day old buds except for a reduction in sterculic acid content. However, one observation is significant, while more sterculic than malvalic acid was present in the bud lipids, the order was reversed in the flower lipids during a short span of only 2 days. Among the various tissues studied only the bud and stem lipids had higher contents of sterculic acid than malvalic acid.

Seed lipids

The seeds matured in 25 days. Lipid synthesis was essentially complete by 16 days after flowering (DAF) (Table 5). The major fatty acids were 18:2, 18:1 and 16:0. Appreciable quantities of 18:3 were also present during the initial stages. The 18:2 content increased until 11 DAF and then decreased slightly. CFA were present throughout although their contents decreased until 16 DAF and then they increased. Small amounts of 17:1 and cyclopropane fatty acids were also present at all stages. The seed oil of *A. rosea* is also reported to contain *ca* 1% epoxy acids [5] which, however, we could not detect.

The lipid contents of roots and stems were maximum in the first sample analysed (25 DAS). In leaves, the lipid content tended to increase until bud formation. The lipid contents of roots, stems and leaves of the young plant were higher than that of the seeds indicating active lipid synthesis from the very early stages of plant growth. In all the tissues the lipid contents decreased with advancing age of the plant probably due to increased formation of other tissue components, especially fibrous matter. Earlier studies [3, 6, 7] have indicated that plants having CFA in their seed lipids also contained them in their root lipids. In a few cases [8, 9] CFA were also detected in other tissues of the plant. In the present investigation CFA were detected in all tissues of *A. rosea* at all stages. Similarly, their precursors (17:1 and 18:1) and intermediates (dihydromalvalic and dihydrosterculic acids) of CFA synthesis [10, 11] were also encountered, albeit in small amounts, in all the tissues.

An examination of Tables 1–3 shows that there is a definite change in the fatty acid composition of the tissue lipids just prior to or during bud formation indicating direct involvement of lipids in this important physiological development of the plant. How

Table 4. Changes in *A. rosea* bud and flower fatty acids during plant growth

Days after sowing	Growth stage	Lipid (% dry wt)	Fatty acids* (wt %)												
			14:0	16:0	16:1	17:1	18:0	18:1	18:2	18:3	20:0	18:1†	19:1†	18:0‡	19:0‡
93	4-day bud	9.5	1.0	36.1	Tr	0.0	5.2	8.8	19.5	23.2	2.4	0.4	3.1	Tr	Tr
97	8-day bud	8.4	0.6	29.7	Tr	Tr	3.4	6.1	21.0	30.3	Tr	2.6	5.7	Tr	Tr
99	Flower	14.2	1.7	29.9	1.7	Tr	4.2	11.7	17.5	27.8	0.6	3.2	1.2	Tr	Tr

*12:0, 22:0 were also present (each <0.6).
†Cyclopropene fatty acids.
‡Cyclopropane fatty acids.
Tr, trace.

Table 5. Changes in *A. rosea* seed fatty acids during plant growth

Days after sowing	Days after flowering	Lipid (% dry wt)	Fatty acids* (wt %)									
			16:0	17:1	18:0	18:1	18:2	18:3	18:1†	19:1†	18:0‡	19:0‡
0	—	10.2	17.8	1.1	2.1	30.3	43.6	0.6	2.9	0.7	Tr	0.8
102	3	7.7	25.2	5.7	0.5	17.8	30.5	10.5	3.7	0.5	1.3	0.8
106	7	8.6	19.8	4.2	0.2	23.4	42.1	6.3	1.0	0.2	Tr	0.1
110	11	11.0	21.1	2.1	0.8	21.5	50.4	2.3	0.4	0.2	Tr	0.3
115	16	13.1	17.8	1.4	3.1	25.3	48.7	0.9	0.3	0.3	Tr	0.6
120	21	13.1	15.5	1.5	2.1	27.3	47.6	0.6	3.5	0.4	0.5	0.9
124	25	13.4	16.0	1.0	1.5	31.0	44.7	0.7	4.2	0.3	Tr	0.3

*12:0 (trace–1.3%), 14:0 (0.1–1.2%) and 22:0 (0.8–1.1%) were also present.
†Cyclopropene fatty acids.
‡Cyclopropane fatty acids.
Tr, trace.

this physiological development affects lipid metabolism, or conversely the role of lipids in this physiological change is at present unknown.

EXPERIMENTAL

A. rosea Cav. (var. Kashmir) was purchased from the local market and was sown in prepared plots. The germination of seeds was better than 90%. Lipids were isolated from 25 to 140 DAS from roots, stems, leaves, buds and flowers at various stages. Seeds were available from 102 DAS and matured in 25 DAF. Lipid extraction and analysis was carried out as described earlier [3].

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