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FATTY ACID COMPOSITION OF THE PHOSPHOLIPIDS OF THE VEGETATIVE  
ORGANS OF THE COTTON PLANT OF VARIETY 159-F AT THE STAGE OF  
MASS FRUIT FORMATION

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The qualitative and quantitative compositions of the fatty acids (FAs) of the individual phospholipids (PLs) of the vegetative organs of the cotton plant of variety 159-F have been studied. In the PLs of the stems there was a wide range of FAs (26), a large proportion of which have retention times in GLC shorter than those of the 16:0 FA. The position distribution of the FAs in the phosphatidylcholine, phosphatidylethanolamine, and phosphatidylinositols of the vegetative organs have been established.

The total fatty acid compositions of all phospholipids (PLs) of the generative organs of the cotton plant and the position distributions of the fatty acids (FAs) in the main PLs — the phosphatidylcholines (PCs), phosphatidylethanolamines (PEs), and phosphatidylinositols (PIs) — have been established previously (see [1]). Continuing work in this direction, we have isolated individual PLs from the vegetative organs — the leaves, bark of the stems, stems without the bark, and roots — and have determined their total fatty acid compositions and the position distributions of the FAs in the PCs, PEs, and PIs.

In the leaves (Table 1), the PL  $X_1$  contain the largest amount of unsaturated FAs, and the degree of unsaturation increased in the sequence  $X_1 > PCs > PAs > PEs > PIs > Y_3$ . The degree of unsaturation in position 2 of the main PLs decreased in the sequence  $PIs > PCs > PEs$ . In the PIs of the leaves there was a pronounced asymmetry of the distribution of the FAs: In position 1 there was 91% of the saturated FAs, of which 37.3% was due to the 16:0 acid, and in position 2 there was 81.8% of the unsaturated FAs, the main representatives of them being the 18:3 acid (51.2%) and the 18:2 acid (26.1%). As in the PLs of the generative organs, in the PLs of the vegetative organs an anomalous distribution of the FAs was observed: In the PCs of the leaves there were larger amounts of the 18:1 and 18:3 acids in position 1 than in position 2, in the PEs the same was observed with the 18:1 FA. In the PL  $X_1$  of the leaves there was more of the 16:1 acid (10.8%), and in the PIs, PEs, and the PL  $X_1$  there was none of the iso-16:0 acid. As compared with all other vegetative and generative organs there was more of the 18:3 acid in the PCs, PIs, and PEs of the leaves, and more unsaturated FAs in the phosphatidic acid (PAs).

The most unsaturated PLs from the bark of the stems were the PAs (Table 2), and the degree of unsaturation decreased in the sequence  $PAs > Y_1 > PEs > Y_4 > PCs > PIs > X_3$ . The asymmetry of the addition of the FAs was pronounced in the PIs (91.3% of saturated FAs in position 1 and 81% of unsaturated FAs in position 2). In the PEs an anomalous addition of more of the 18:3 FA in position 1 than in position 2 was observed. The 20:0 acid was present only in the PIs and PCs. The PEs of the bark contained more of the 18:2 acid than the PEs of the other organs.

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TABLE 1. Compositions and Position Distributions of the Fatty Acids in the Phospholipids from the Leaves

Fatty acid	PIs		PCs		PEs		FAs	x <sub>1</sub>	y <sub>2</sub>
	tot.	pos. 2	tot.	pos. 2	tot.	pos. 2			
9:0	0,1	0,1	0,1	0,1	—	—	—	—	—
10:0	—	—	0,1	0,1	—	—	—	0,8	0,7
Unidentified	—	—	0,2	0,2	0,4	—	0,2	—	—
12:0	—	—	0,1	0,1	0,2	—	0,3	0,1	0,7
14:0	0,9	0,4	0,3	0,4	0,8	0,3	0,6	0,7	1,9
Unidentified	1,6	0,4	0,4	0,3	0,6	0,3	0,7	0,5	1,2
Iso-16:0	—	—	0,3	—	—	—	0,4	—	1,0
16:0	35,9	14,5	32,6	22,5	34,8	11,8	32,9	21,6	30,7
16:1	1,9	0,9	0,6	0,7	2,6	2,8	2,0	10,8	2,0
Unidentified	2,1	0,7	0,9	0,4	8,5	15,7	1,4	—	2,9
2:3	—	—	—	—	—	—	—	—	2,5
Iso -18:0	0,5	0,8	0,9	0,6	0,3	0,4	0,8	0,8	—
18:0	3,2	1,3	2,5	2,4	1,8	1,8	3,0	2,2	5,9
18:1	4,2	3,6	4,6	6,3	4,1	3,2	5,6	5,7	6,7
Unidentified	3,5	—	—	—	—	—	—	—	—
18:2	13,3	26,1	17,3	14,1	14,5	23,0	6,2	3,9	14,3
20:0	4,5	—	—	—	2,1	0,5	3,3	—	8,5
18:3	26,0	51,2	39,1	51,9	29,3	38,2	32,6	52,9	21,0
Σ <sub>S</sub>	54,6	18,2	38,4	27,0	49,5	30,8	43,6	26,7	56,0
Σ <sub>U</sub>	45,4	81,8	61,6	73,0	50,5	69,2	56,4	73,3	44,0

TABLE 2. Composition and Position Distribution of the Fatty Acids in the Phospholipids from the Bark of the Stems

Fatty acid	PIs		PCs		PEs		FAs	y <sub>1</sub>	x <sub>2</sub>	y <sub>2</sub>
	tot.	pos. 2	tot.	pos. 2	tot.	pos. 2				
9:0	0,8	—	0,2	0,1	0,5	0,1	—	0,1	—	—
10:0	—	—	—	—	—	—	—	0,2	1,0	—
Unidentified	0,7	—	4,0	0,7	0,1	—	—	4,8	—	2,0
12:0	—	—	0,1	0,1	—	—	—	—	0,8	—
Iso-14:0	4,3	—	0,5	0,3	1,4	0,1	0,3	0,3	0,3	-0,3
14:0	0,1	0,1	0,1	0,1	0,2	0,2	—	—	—	—
14:0	5,2	0,7	1,6	0,5	0,6	1,0	—	—	0,7	—
Iso-15:0	—	—	—	—	0,1	0,1	0,3	1,2	—	0,8
Anteiso-15:0	0,2	0,3	—	—	0,4	0,1	—	—	—	—
Unidentified	2,9	0,7	0,9	0,3	0,5	0,8	0,4	0,6	0,7	0,7
Iso-16:0	0,2	0,3	0,4	0,3	0,3	0,2	0,4	—	0,6	—
16:0	23,9	19,3	29,1	14,1	31,3	22,1	25,0	26,8	49,2	33,2
16:1	1,3	1,5	1,8	1,4	1,5	2,8	0,9	2,5	1,5	1,7
Unidentified	6,7	0,6	1,3	0,3	0,9	1,3	0,7	1,2	0,9	1,3
Iso-18:0	1,0	1,1	1,2	1,2	1,3	0,8	0,8	—	1,0	—
18:0	10,7	3,2	3,5	1,4	2,6	4,4	2,8	3,7	4,8	3,1
18:1	6,9	7,2	10,4	8,8	7,0	12,4	8,6	14,5	6,6	9,9
18:2	19,5	38,6	26,6	38,3	35,0	38,3	37,7	32,5	17,6	32,1
20:0	2,1	—	2,3	0,5	—	—	—	—	—	—
18:3	13,5	26,4	16,0	31,6	16,3	15,3	22,1	11,6	14,3	14,9
Σ <sub>S</sub>	58,8	26,3	45,2	19,9	40,2	31,2	30,7	38,9	60,0	41,4
Σ <sub>U</sub>	41,2	73,7	54,8	80,1	59,8	68,8	69,3	61,1	40,0	58,6

As compared with the PLs of the bark, the PLs of the stems contained a larger set of FAs (Table 3). In the PCs there were more unsaturated FAs, and the PLs formed the following sequence of increasing unsaturation: PAs > PEs > PCs > PIs > Y<sub>3</sub> > Y<sub>5</sub> > Y<sub>1</sub> > X<sub>1</sub>. There was an increased amount of the 16:1 FA in the PL Y<sub>1</sub> the PEs, and the PIs. On the whole, for the PIs, PCs, and PEs no anomalous distribution of the fatty acids was observed but it was observed in relation to the 16:0 and 18:3 acids in the PIs and the 18:1 acid in the PCs and PEs.

The phosphatidylinositols of the leaves of the bark and stems usually came after the PCs and PEs with respect to their content of unsaturated FAs, but in the roots they came first (Table 4): PIs > PCs > PEs > PAs > Y<sub>1</sub> > X<sub>1</sub>. There were large amounts of the 15:1 FA in the PIs, PAs, Y<sub>1</sub>, and PEs. The PL X<sub>1</sub> contained more of the 9:0 acid (16.0%) than the PLs of the other organs. There were more saturated acids (Σ<sub>S</sub> 93.2%) than in the other PLs. An anomalous addition of FAs was observed in the case of the 18:1 acid in the PIs and PCs and the 16:1 acid in the PIs.

TABLE 3. Composition and Position Distributions of the Fatty Acids in the Phospholipids from the Stems without Bark

Fatty acid	PIs		PCs		PEs		PAs	y <sub>1</sub>	x <sub>1</sub>	y <sub>3</sub>	y <sub>5</sub>
	tot.	pos. 2	tot.	pos. 2	tot.	pos. 2					
9:0	—	—	0,2	0,2	0,5	0,1	—	—	0,7	—	—
10:0	—	—	1,0	1,8	0,4	0,4	0,1	2,5	5,6	1,7	—
Unidentified	5,4	0,6	1,3	—	0,2	0,1	1,0	6,2	—	7,9	7,2
11:0	0,1	0,1	0,2	0,1	—	—	—	—	—	—	—
Unidentified	—	—	0,2	0,3	0,6	—	—	—	1,9	—	—
12:0	5,2	0,6	1,3	0,8	2,2	0,4	1,1	7,3	5,4	4,9	—
Unidentified	6,8	1,2	3,3	—	1,1	—	0,8	3,6	—	Tr.	—
0,6	—	—	—	—	—	—	—	—	—	—	—
Iso-14:0	0,3	—	—	—	0,1	0,1	—	—	—	—	—
14:0	1,9	1,9	0,4	0,6	1,2	0,9	0,7	1,9	0,8	0,9	1,8
Iso-15:0	—	—	—	—	0,3	—	—	—	1,8	—	—
Anteiso-15:0	0,3	0,6	0,5	—	0,3	—	0,1	—	—	—	—
Unidentified	1,0	1,3	1,1	0,8	1,3	0,6	0,7	1,5	1,7	0,8	1,8
Iso-16:0	0,5	0,5	0,6	0,5	0,6	0,2	0,7	—	0,6	0,4	0,7
16:0	32,5	34,6	32,9	30,5	33,6	22,0	29,1	27,9	45,5	37,6	38,0
16:1	2,5	2,9	1,3	0,8	2,7	1,1	1,1	4,9	3,3	1,2	3,1
Unidentified	1,0	1,5	0,9	0,7	1,1	0,4	2,0	2,6	1,9	0,9	2,0
Iso-18:0	—	—	0,3	0,4	0,9	0,5	—	—	—	—	—
18:0	1,4	0,9	1,1	1,0	1,0	0,6	2,6	3,1	1,1	2,1	3,0
18:1	1,6	2,3	4,9	1,1	3,0	1,1	0,9	5,7	4,9	3,5	6,7
18:1	4,9	7,6	9,9	8,9	6,9	5,4	5,8	5,8	5,7	5,4	6,9
Unidentified	—	—	—	—	2,0	—	—	—	1,6	—	—
18:2	19,7	34,5	24,8	35,3	28,2	50,3	35,8	16,3	10,9	23,9	21,0
20:0	1,3	1,6	2,2	1,5	1,9	1,3	1,6	—	4,6	—	—
18:3	13,0	7,3	11,6	14,7	9,9	14,5	15,9	10,7	2,0	8,8	7,8
Σ <sub>S</sub>	59,9	47,7	52,4	40,3	52,3	28,7	41,4	62,3	78,1	60,7	61,2
Σ <sub>U</sub>	40,1	52,3	47,6	59,7	47,7	71,3	58,6	37,7	21,9	39,3	38,8

TABLE 4. Composition and Position Distributions of the Fatty Acids in the Phospholipids from the Roots

Fatty acid	PIs		PCs		PEs		PAs	y <sub>1</sub>	x <sub>1</sub>
	tot.	pos. 2	tot.	pos. 2	tot.	pos. 2			
9:0	—	—	—	—	—	—	—	—	16,0
10:0	0,2	0,2	—	—	—	—	—	—	—
Unidentified	—	—	0,2	0,2	0,1	0,1	—	—	—
12:0	0,1	0,1	0,2	0,3	0,2	0,2	3,2	2,9	39,0
Iso-14:0	0,1	0,1	—	—	0,2	0,2	—	—	—
14:0	2,9	0,4	0,5	0,8	3,4	1,4	4,0	4,8	—
Iso-15:0	0,5	—	—	—	0,3	0,4	—	—	—
Anteiso-15:0	0,2	0,2	—	—	0,4	0,6	—	—	—
Unidentified	2,2	0,4	0,5	0,6	2,6	1,5	3,2	3,5	2,8
Iso-16:0	0,7	0,3	0,2	0,3	0,2	0,2	—	—	—
16:0	30,0	13,5	45,0	21,0	33,3	25,3	45,2	44,8	28,0
16:1	5,6	1,2	1,2	1,6	3,6	4,1	4,8	4,0	2,4
Unidentified	2,4	0,6	0,6	0,8	3,7	2,4	2,5	7,4	3,6
Iso-18:0	2,2	0,9	0,6	0,8	0,8	1,4	—	—	—
8:0	7,1	1,4	2,1	2,1	8,7	6,2	7,0	14,9	3,8
18:1	7,9	7,9	11,0	12,9	13,4	9,4	9,3	9,9	4,4
18:2	21,0	41,4	26,0	38,0	14,7	18,9	13,0	5,1	Tr.
20:0	0,9	—	—	—	1,2	2,1	—	—	—
18:3	16,0	31,4	11,9	20,6	13,2	25,6	7,8	2,7	Tr.
Σ <sub>S</sub>	49,5	18,1	49,9	26,9	55,1	42,0	65,1	78,3	93,2
Σ <sub>U</sub>	50,5	81,9	50,1	73,1	44,9	58,0	34,9	21,7	6,8

On comparing the fatty acid compositions of the PLs of the vegetative organs, it is possible to observe the following situation: The amounts of the 18:0 acid in the PCs, the 18:1 acid in the PEs, and the 18:2 acid in the PIs increased from the leaves to the roots; the amount of the 18:3 acid in the PAs and in the PL Y<sub>1</sub>, of the 20:0 acid in the PIs, and of the 18:2 acid in the PL Y<sub>1</sub> decreased from the leaves to the roots; the amount of the 16:0 and 18:0 saturated acids in the PL Y<sub>1</sub> increased from the roots to the bark; the amount of the 16:0 acid in the PL Y<sub>3</sub> increased from the leaves to the stem; the total unsaturation of the PEs rose from the leaves to the roots.

Generalizing the results of our study of the fatty acid compositions of the generative and vegetative organs of the cotton plant of variety 159-F at the stage of mass fruit-bearing the following can be said: The PL X<sub>1</sub> in all the organs apart from the leaves is the most saturated fraction, and the PAs from the bark the most unsaturated. The amount of the 18:0 acid in the PIs from the bark is unusually high, and the amount of FAs in the developing organs is three times more than in the ripe seeds [2], which explains the presence of the far larger number of molecular species of PLs that the plant organism requires. Of the total number of fatty acids, more than half is represented by FAs with shorter retention times on FLC than the 16:0 FA, and the PLs of the stems contain the largest set of FAs and the PLs of the leaves the smallest set, in comparison with the other organs. Anomalous features of the addition of the FAs in the PLs are explained by the necessity for the formation of membranes in these organs, which does not exclude the possibility that these PLs are specific for the membranes of the organelles of the cotton-plant organs studied.

#### EXPERIMENTAL

The investigation was performed as described in [1].

#### SUMMARY

1. The qualitative and quantitative compositions of the fatty acids of the individual phospholipids of the vegetative organs of the cotton plant — the leaves, the bark of the stems, the stems without the bark, and the roots — have been studied. The stems have the largest range of fatty acids (26) and a large proportion of them have retention times in GLC shorter than that of the 16:0 acid.

2. The position distribution of the fatty acids in the phosphatidylcholines, phosphatidylethanolamines, and phosphatidylinositols in the vegetative organs have been established: The unsaturated acids predominate in position 2 and the saturated acids in position 1, but there are deviations and the possibility that this situation is necessary for the developing plant is not excluded.

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#### PHOSPHOLIPIDS OF *Phaseolus aureus*. II

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The fractional and fatty-acid compositions of the total phospholipids of the mung bean of the Angelika variety have been studied. It has been established that the compositions of the fatty acids of the total phospholipids of this variety and of the variety of mung bean studied previously, and their individual fractions, differed quantitatively from one another.

Continuing an investigation of the phospholipids (PLs) of the mung bean *Phaseolus aureus* Roxb. [1], we have studied the phospholipids of the seeds of the variety Angelika from the 1976 harvest collected in the experimental station of the Central Asian Branch of VIR [N. I. Vavilov All-Union Scientific-Research Institute of Plant Husbandry].

The isolation of the total PLs and their purification from accompanying substances were carried out as described previously [1]. The yield of the purified total PLs was 1.4% on the total weight of the air-dry seeds.

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