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DISTRIBUTION OF PHOSPHOLIPIDS IN THE ORGANS OF THE COTTON PLANT IN THE PERIOD OF MASS FRUIT-FORMATION

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The distribution of phosphorus in the vegetative and generative organs of the cotton plant of variety 159-F has been studied. It has been established that the various organs of the cotton plant differ with respect to the qualitative and quantitative compositions of their phospholipids.

The maximum amount of unidentified phospholipids (PLs) in the seeds of the cotton plant of variety 159-F is found at the stage of massive fruit-formation [1, 2]. There are reports on the amount of total phosphorus in different generative and vegetative organs of the cotton plant [3, 4], and some authors [5-9] have determined the amounts of lipid phosphorus in the leaves and in the whole bush. We have studied the distribution of phospholipids in the vegetative and generative organs of the cotton plant of variety 159-F in the period of mass fruit-formation. The yield of extractive substances, the distribution of total phosphorus, and the amount of lipid phosphorus in the various organs of one cotton bush — buds, flowers of the 1st day, flowers of the 2nd day, bolls, leaves, bark of the stem, stem without the bark, and roots — have been determined. The amounts of phosphorus and phospholipids were determined in chloroform-methanolic (2:1), methanolic, and aqueous extracts and in the meal (Tables 1 and 2).

It follows from the figures given in Table 1 that the largest amounts of substances are extracted by chloroform-methanol and by methanol from the leaves and stems. The amounts of extractive substances decrease in the sequence: leaves > stems without bark > bolls > buds > bark > flowers > roots. But if we compare these results with the ratios of the weights of the organ to the weight of the cotton bush, which will show the relative secretion of the extractive substances, we obtain a somewhat different sequence: stems without bark > leaves > buds > flowers > bolls > bark > roots. The amount of phosphorus in the organs changes in

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TABLE 1. Yield of Extracts from the Cotton Plant of Variety 159-F, %

Organ of the cotton plant and extract* from it	Ratio of the organ and the cotton bush, %	Yield of extractive substances, %			
		on the bush	on the organ	on the extractive substance	
				bush	organ
Buds	3.98	0.230	23.8	4.4	100.0
Chl-M		0.046	1.1	0.9	19.9
M		0.012	0.3	0.2	5.1
H ₂ O		0.172	4.3	3.3	75.0
Meal		—	18.1	—	—
Flowers of the 1st day	0.65	0.040	20.5	0.7	100.0
Chl-M		0.006	1.0	0.1	15.9
M		0.001	0.2	0.02	3.2
H ₂ O		0.033	5.1	0.6	80.9
Meal		—	14.2	—	—
Flowers of the 2nd day	0.62	0.038	21.7	0.5	100.0
Chl-M		0.006	0.9	0.1	15.5
M		0.002	0.3	0.04	5.2
H ₂ O		0.030	4.7	0.6	79.3
Meal		—	15.8	—	—
Bolls	30.71	1.502	19.7	29.2	100.0
Chl-M		0.160	0.5	3.1	10.7
M		0.068	0.2	1.3	4.5
H ₂ O		1.274	4.1	24.8	84.8
Meal		—	14.9	—	—
Leaves	35.59	2.112	25.3	41.0	100.0
Chl-M		0.671	1.9	13.0	31.8
M		0.136	0.4	2.6	6.4
H ₂ O		1.305	3.4	25.4	61.8
Meal		—	19.6	—	—
Bark of the stems	10.09	0.517	28.1	10.1	100.0
Chl-M		0.051	0.5	1.1	9.8
M		0.006	0.1	0.1	1.1
H ₂ O		0.460	4.6	8.9	89.1
Meal		—	22.9	—	—
Stems without bark	12.97	0.652	41.8	12.7	100.0
Chl-M		0.042	0.3	0.8	6.5
M		0.294	2.3	5.7	45.2
H ₂ O		0.315	2.4	6.2	48.3
Meal		—	36.8	—	—
Roots	5.39	0.077	11.8	1.4	100.0
Chl-M		0.013	0.2	0.2	16.7
M		0.001	0.02	0.02	1.7
H ₂ O		0.063	1.2	1.2	81.6
Meal		—	10.4	—	—

*Here and in Table 2: Chl-M — chloroform-methanolic (2:1);
M — methanolic; H₂O — aqueous extract.

the sequence buds > flowers > leaves > bark > bolls > stems without bark > roots. The amount of phosphorus in the organs in relation to the total amount of phosphorus in the whole bush and to the total amount of extractive phosphorus of the whole bush decreases in the sequence leaves > bolls > stems > buds > flowers > roots. The ratio of the amount of phosphorus in an organ as a fraction of the total amount of phosphorus in the cotton bush to the weight of the organ as a fraction of the total weight of the bush shows that the relative amount of phosphorus is greatest in the buds, flowers, and leaves, and then it decreases in the sequence bark > bolls > stems without bark > roots. The amount of lipid phosphorus decreases in the sequence stems without bark > flowers of the 1st day > bark > flowers of the 2nd day > bark > bolls > leaves > buds.

The high amount of phosphorus in the buds and leaves probably shows the special role of it in these intensively developing organs of the cotton plant. An increased amount of phosphorus in the leaves and bark of the stems corresponds to the function of photosynthesis and the transfer of materials to all the plant organs. The intensity of the formation and the role of phosphorus compounds are dissimilar, as can be followed for the case of the lipid phosphorus. Phospholipids form one of the main components of the cell membranes and the distribution of lipid phosphorus shows the degree of development and growth of the plant organs. The roots and stems have practically completed their growth during the period of mass fruit-bearing and therefore there is little lipid phosphorus in them, since the cell membranes have already been formed and the supply of necessary substances, including phosphorus compounds, takes place through them. In the flowers, the creation of the cell mem-

TABLE 2. Amounts and Distribution of Phosphorus in the Organs of the Cotton Plant of Variety 159-F

Organ of the cotton plant and extracts from it	Phosphorus, %					Lipid phosphorus to total phosphorus from the organ
	in the organ in the fraction	in the fraction to the total phosphorus				
		in the bush	in the organ	extractable from		
				bush	organ	
Buds	0.033	6.64	100.00	5.54	100.00	
Chl-M	0.48	1.10	16.54	2.29	41.32	
M	0.76	0.44	6.64	0.92	16.59	2.9
H ₂ O	0.13	1.12	16.85	2.33	42.09	
Meal	0.11	3.98	59.97	—	—	
Flowers of the 1st day	0.026	0.84	100.00	1.09	100.00	
Chl-M	10.4	0.33	39.68	0.70	64.20	
M	0.86	0.06	6.56	0.12	10.62	35.6
H ₂ O	0.08	0.13	15.57	0.27	25.18	
Meal	0.07	0.32	38.19	—	—	
Flowers of the 2nd day	0.033	1.04	100.00	1.25	100.00	
Chl-M	1.14	0.33	31.71	0.69	55.20	
M	1.09	0.11	10.11	0.22	17.59	21.5
H ₂ O	0.11	0.16	15.63	0.34	27.21	
Meal	0.09	0.44	42.55	—	—	
Bolls	0.015	23.40	100.00	24.85	100.00	
Chl-M	0.43	3.45	14.74	7.20	28.97	
M	0.42	1.43	6.13	2.99	12.05	11.4
H ₂ O	0.11	7.02	30.02	14.66	58.98	
Meal	0.05	11.50	49.11	—	—	
Leaves	0.028	50.76	100.00	47.55	100.00	
Chl-M	0.50	16.32	33.14	35.09	73.79	
M	0.59	4.02	7.90	8.37	17.60	6.4
H ₂ O	0.03	1.96	3.87	4.09	8.61	
Meal	0.08	27.96	55.09	—	—	
Bark of the stems	0.017	8.61	100.00	8.28	100.00	
Chl-M	1.08	2.75	31.94	5.74	69.24	
M	1.03	0.30	3.47	0.62	7.52	25.0
H ₂ O	0.04	0.92	10.72	1.92	23.24	
Meal	0.04	4.64	53.87	—	—	
Stems without bark	0.012	7.63	100.00	10.93	100.00	
Chl-M	0.65	1.38	18.11	2.88	26.38	
M	0.24	3.54	46.40	7.39	67.59	46.0
H ₂ O	0.02	0.32	4.13	0.66	6.03	
Meal	0.01	2.39	31.36	—	—	
Roots	0.004	1.08	100.00	0.51	100.00	
Chl-M	0.26	0.17	15.51	0.35	69.52	
M	0.65	0.04	3.88	0.09	17.38	14.3
H ₂ O	0.01	0.03	2.92	0.07	12.10	
Meal	0.63	0.84	77.69	—	—	

TABLE 3. Qualitative and Quantitative Compositions of the Phospholipids in the Organs of the Cotton Plant of Variety 159-F

Organ	Amount, %								
	Y ₁	PI	PC	N ₁	PE	PA	Y ₂	N ₂	Y ₃
Buds	5.6	9.5	41.3	3.0	8.0	11.2	8.2	3.8	—
Flowers of the 1st day	3.8	10.1	42.7	5.6	10.9	5.2	7.6	9.3	3.5
Flowers of the 2nd day	4.7	15.8	43.6	3.4	9.1	17.2	3.5	—	2.7
Bolls	7.6	13.1	35.4	6.3	8.8	19.1	4.6	5.1	—
Leaves	—	31.3	21.2	12.1	24.2	9.0	2.2	—	—
Bark of the stems	7.6	10.6	28.5	—	17.4	23.9	7.4	4.6	—
Stems without bark	4.3	13.0	17.7	10.1	13.1	37.4	3.6	—	0.8
Roots	5.9	10.5	38.7	8.0	2.6	35.2	—	—	—

branes is also complete, but the different phosphorus contents of the flowers of the first and second days is due to the fact that the first were collected almost immediately after their opening and, even if pollination had already taken place, they had not had time to change, in comparison with the flowers of the second day the pollination of which was practically complete and which had begun their transformation, which is characterized by a decreased content of lipid phosphorus and an increased amount of phosphorus in comparison with the flowers of the 1st day. The lowest amount of lipid phosphorus and the high amount of phosphorus in the buds show that the phosphorus-containing substances necessary for development have passed into the buds for their further transformation and, in particular, for the formation of cell membranes. The same applies to the bolls. The low amount of lipid phos-

phorus in the leaves is due to the fact that in the main the building of the cell membranes has ended and the main work of the cells — photosynthesis, which is impossible without the participation of phosphorus-containing substances — is being performed.

The qualitative and quantitative compositions of the phospholipids of the various organs of the cotton plant are dissimilar (Table 3).

In six of the eight organs phosphatidylcholine (PC) predominates, its amount decreasing in the sequence flowers of the 2nd day > flowers of the 1st day > buds > roots > bolls > bark > leaves > stems without bark. The largest amount of phosphatidylinositol (PI) in the leaves and its amount in the other organs ranges from 9.5% (buds) to 15.8% (flowers of the 2nd day). There is more phosphatidylethanolamine (PE) in the leaves and bark and less in the roots. There is more phosphatidic acid (PA) in the stems without bark and in the roots and least of all in the flowers of the 1st day and the leaves. Being absent from the leaves, an unidentified minor phospholipid Y_1 is concentrated in the bolls and in the roots. In comparison with the other organs, there is more of phospholipid X_1 in the leaves and the stems without bark, of phospholipid Y_3 in the buds, the flowers of the first day, and the roots, and of phospholipid X_3 in the flowers of the first day. An unidentified minor phospholipid Y_5 , having R_f 0.15 in system 1 and 0.2 in system 2 has been detected only in the flowers and the stems without bark. Thus, each organ has its qualitative and quantitative phospholipid composition.

EXPERIMENTAL

The cotton plant was grown to the stage of mass fruit-bearing using the usual agricultural techniques in the G. S. Zaitev All-Union Scientific Research-Institute of Selection and Seed Production.

The isolation of the phospholipids and subsequent work was performed as described previously [2].

SUMMARY

1. The distribution of phosphorus in the stage of mass fruit-bearing the vegetative and generative organs and in extracts and meal from them has been studied. The amounts of total and lipid phosphorus in an organ showed the degree of its development and preparation for transformation and depend on the function of each organ.

2. It has been established that the amounts of the main phospholipids in the organs of the cotton plant vary within the following limits: phosphatidylcholine from 43.6 to 10.5%; phosphatidylinositol from 15.8 to 9.5%; phosphatidylethanolamine from 24.2 to 2.6%; phosphatidic acid from 37.4 to 6.2%. Each organ has its own qualitative and quantitative phospholipid composition.

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