PHOSPHOLIPIDS OF KENAF DURING ITS GROWTH

I. Tolibaev, Kh. S. Mukhamedova, and S. T. Akramov

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The change in the fractional and fatty-acid compositions of the total phospholipids in various organs of kenaf during its growth has been studied. It has been found that phospholipids are synthesized in all stages of the development of kenaf, but most intensively during its ripening.

The phospholipid complex in the process of ripening of plant seeds has been studied fairly broadly [1-8], but there is little information in the literature on the changes in the quantitative, fractional, and fatty-acid compositions of the phospholipids of various plant organs during the vegetation phases [9]. We have investigated the phospholipids of various organs of kenaf (*Hibiscus cannabinus*) of the industrial variety Uzbekskii-1503 in the process of its growth. Samples were taken from a field of the Uzbek Experimental Station of Bast Crops at the Ministry of Agriculture of the UzSSR from the moment of incipient vegetation to complete ripening. The sums of the lipids from the various organs of the plant were obtained by generally known methods [10, 11] and were freed from contaminating carbohydrates by gel filtration on Molselekt. The phospholipids were isolated from the lipid fraction by adsorption chromatography on a column of silica gel. The quantitative distribution of the individual fractions of the phospholipids in the total was determined by two-dimensional thin-layer chromatography with respect to the amount of phosphorus in the corresponding spots on the chromatograms in solvent systems 1 (direction I) and 2 (direction II) [12, 13] (Table 1). Analysis of the results obtained (see Table 1) indicates large changes both in the amount and in the quantitative composition of the total phospholipids of the various organs during the growth of kenaf. In particular, in the leaves and roots the amount of phospholipid complex decreased uniformly, and from the beginning of flowering to complete ripening of the seeds the maximum amounts of phospholipids was found in the buds and in the seeds, respectively [9].

In the process of development of kenaf, the quantitative and qualitative compositions of the individual fractions of phospholipids likewise change considerably: The amounts of PC, PE, N-acyl-E, and N-acyllyso-PE in all the organs, with some exceptions, increase and the amount of PI decrease. Phosphatidic acids (PA), which are completely absent from the roots in all stages of the growth of kenaf, also disappear completely from the seeds from the period of fruit-bearing onwards, just like the phosphatidylglycerols (PG). As is well known, the biosynthesis of phospholipids is closely connected with the oil-forming process, and some lipids — particularly the phosphatidic acids (PA) and phosphatidylglycerols (PG) — participate in the synthesis of triglycerides. This fact possibly also explains the absence of these phospholipids from kenaf seeds [14]. As they ripen, the amounts of PC and PE in the seeds increases considerably and the amount of PI decreases nonuniformly. A similar tendency has also been reported in a study of the phospholipids of wheat and maize in the process of ripening of the grain [3, 15, 16].

At the stage of incipient fruit-bearing traces of an unidentified phospholipid appear in the seeds, the amount of which in the ripe seeds reaches 2.8% of the total phospholipids. The structure of this phospholipid has not yet been established, which is due to certain difficulties in its isolation from the total phospholipids.

The separate total phospholipids obtained from various organs of kenaf were deacylated by alkaline saponification and the fatty acids (FA) split out were analyzed in the form of their methyl esters by GLC (Table 2). In the process of the growth of kenaf, the fatty acid compositions of the phospholipids undergo considerable quantitative changes, and the S:U

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TABLE 1. Amount and Fractional Composition of the Phospholipids of Various Organs of Kenaf according to Phases of Vegetation

Date of collection, phase of development, and organ of the plant (1979)	Yield ΣPL, %	Quantitative composition of the phospholipid fract., %							
		PC	PI	PE	PA	PG	N-acyl-PE	N-acyl-lyso-PE	un-ident. PL
May 24, incipient vegetation									
Leaves	0,50	15,8	31,6	14,7	14,6	13,6	7,0	2,7	—
Stems	0,17	17,5	33,9	13,5	11,4	15,9	5,7	2,1	—
Roots	0,40	20,3	40,0	14,9	—	17,2	5,3	2,3	—
June 15, incipient budding									
Leaves	0,47	19,2	26,7	15,2	15,2	13,1	7 5	3,1	—
Stems	0,10	20,6	26,1	15 5	12,9	15,3	7,2	2,4	—
Roots	0,35	22,1	33,5	15,1	—	19,0	7,8	2,5	—
July 5, incipient flowering									
Buds	0,41	30,0	27,2	15,3	7,4	9,7	7,7	2,7	—
Flowers	0,32	30,4	30,0	15,2	5,8	8,5	7,0	3,1	—
Leaves	0,40	23,1	25,0	16,0	13,5	11,4	7,8	3,2	—
Stems	0,20	23,7	25,2	15,0	12,6	15,0	6,2	2,3	—
Roots	0,33	26,5	31,8	16,1	—	15,7	7,5	2,4	—
July 25, incipient fruit-bearing									
Unripe seeds	0,42	34,0	36,5	18,7	Tr.	Tr.	8,3	2,5	Tr.
Leaves	0,40	29,0	24,3	16,7	8,7	11,1	7,8	2,4	—
Stems	0,18	26,4	28,9	15,9	7,8	13,2	5,3	2,5	—
Roots	0,25	29,9	30,0	16,2	—	13,6	7,8	2,5	—
August 15, fruit-bearing									
Unripe seeds	0,73	37,0	30,7	19,4	—	—	9,1	3,8	Tr.
Leaves	0,30	29,3	23,3	18,3	10,4	7,9	7,9	2,9	—
Stems	0,12	27,4	24,0	18,8	8,1	10,7	8,1	2,9	—
Roots	0,20	32,9	29,9	16,2	—	10,6	8,1	2,3	—
Sept. 4, fruit-bearing									
Unripe seeds	0,80	38,2	25,8	20,2	—	—	9,0	4,1	2,7
Leaves	0,25	33,7	25,7	17,6	7,6	5,2	7,6	2,6	—
Stems	0,12	31,3	24,7	19,4	3,9	8,4	9,7	2,6	—
Roots	0,18	33,6	26,9	18,4	—	9,1	9,1	2,9	—
Sept. 25, end of fruit-bearing									
Leaves	1,0	39,7	22,9	21,0	—	—	9,3	4,3	2,8
Stems	0,10	29,4	31,9	20,0	Tr.	5,9	9,8	3,0	—
Roots	0,15	31,2	27,4	21,4	—	6,3	9,4	4,3	—

TABLE 2. Fatty-Acid Composition of the Total Phospholipids of the Organs of Kenaf in Various Stages of Vegetation

Phase of development and plant organ	Fatty acid										
	10:0	12:0	14:0	16:0	16:1	18:0	18:1	18:2	18:3	$\Sigma_{П}$	$\Sigma_{Н}$
Incipient vegetation											
Leaves	0,3	0,2	0,5	30,8	10,5	4,0	3,6	18,9	31,2	35,8	64,2
Stems	—	2,9	2,9	30,2	5,6	5,3	6,8	31,5	14,8	41,3	58,7
Roots	—	2,6	3,0	35,7	6,4	5,1	8,7	27,5	11,0	46,4	53,6
Incipient budding											
Leaves	Tr.	Tr.	0,4	28,7	7,9	2,8	2,8	20,7	36,7	31,9	68,1
Stems	0,2	—	0,5	23,3	1,7	2,5	5,4	45,8	20,6	26,5	73,5
Roots	0,7	0,3	1,3	36,1	2,9	3,4	7,3	33,4	14,6	41,8	58,2
Incipient flowering											
Buds	12,1	4,6	1,9	19,3	2,7	4,1	16 4	28,4	10,5	42,0	58,0
Flowers	1,3	2,3	1,1	29,5	1,3	5,5	14,8	30,4	13,8	39,7	60,3
Leaves	1,4	2,8	2,6	40,6	6,9	6,6	5,3	12,9	20,9	54,0	46,0
Stems	1,9	0,6	1,4	42,7	2,8	5,9	8,4	22,1	14,2	52,5	47,5
Roots	3,2	1,5	2,2	42,1	3,4	6,0	11,5	21,0	9,1	55,0	45,0
Incipient fruit-bearing											
Unripe seeds	6,7	9,4	2,4	32,3	2,7	4,3	10,4	23,7	8,1	55,1	44,9
Leaves	2,0	3,2	1,0	31,6	3,8	5,0	6,5	20,6	26,3	42,8	57,2
Stems	4,5	6,4	1,6	29,7	2,2	4,4	17,2	29,5	4,5	46,6	53,4
Roots	2,9	2,1	2,2	33,2	6,9	4 0	10,0	27,2	11,5	44,4	55,6
Fruit-bearing											
Unripe seeds	4,0	5,7	3,4	32,0	6,5	5,6	12,2	26,3	4,3	50,7	49,3
Leaves	2,5	4,6	1,5	34,8	3,3	6,9	15,8	10,2	20,4	50,3	49,7
Stems	6,6	10,3	2,6	27,9	2,7	4,7	14,0	24,5	6,7	52,1	47,9
Roots	3,4	4,5	1,9	34,1	2,4	4,8	12,7	27,8	8,4	48,7	51,3
Unripe seeds	0,3	0,3	0,4	29,4	1,5	2,5	16 5	45,5	3,6	32,9	67,1
Leaves	0,8	—	0,5	25,4	4,1	4,4	3,6	22,1	39,1	31,1	68,9
Stems	—	2,5	1,3	31,9	2,3	4,7	9,1	32,5	15,7	40,4	59,6
Roots	2,5	1,4	1,4	33,4	5,0	4,8	6,2	25,3	20,0	43,5	56,5
End of fruit-bearing											
Leaves	1,4	1,6	0,4	20,2	0,7	1,5	26,1	46,4	1,7	25,1	74,9
Stems	16,6	14,3	4,9	22,7	4,5	7,0	12,2	13,0	4,8	65,5	34,5
Roots	7,0	9,4	1,8	29,1	4,5	5,1	12,5	23,5	7,1	52,4	47,6

ratio varies continuously. It is interesting to note that in all the stages of development in all the organs of kenaf among the saturated acids the 16:0 compound predominates while among the unsaturated acids the 18:3 acid predominates in the leaves and the 18:2 acid in the stems and roots.

In the initial phase of ripening, there is a larger amount of saturated acids in the unripe seeds than in the final stage. From the beginning of fruit-bearing the amounts of 16:0 and 18:3 acids in the seeds decrease uniformly (from 32.3 to 20.0% and from 8.1 to 1.7%, respectively), while the amounts of the 18:1 and 18:2 acids increase uniformly (from 10.4 to 26.1% and from 23.7 to 46.4%, respectively), the accumulation of linoleic acid taking place more intensively, which is in harmony with information in the literature [17]. Consequently, the 16:0, 18:1, 18:2, and 18:3 acids actively participate in the biosynthesis of phospholipids during the growth of kenaf and the difference in the composition of the fatty acids of the total phospholipids possibly depends on their role in metabolism and the specificity of acylation in the biosynthesis of phospholipids.

EXPERIMENTAL

From chromatography we used KSK silica gel; 125 μ for thin-layer chromatography and 160-250 μ for column chromatography. The solvents were purified by generally known methods [18]. For two-dimensional chromatography we used the following solvent systems: 1) chloroform–methanol–25% ammonia (14:6:1); and 2) chloroform–acetone–methanol–acetic acid–water (5:2:1:1:0.5). The alkaline deacylation of the total phospholipids was carried out as described by Stahl [19]. Conditions for GLC: Khrom-41 chromatograph with a flame-ionization detector using a steel column (2500 × 3 mm) containing Celite-545 impregnated with 17% of PEGS. The carrier gas was helium at the rate of 30 ml/min.

SUMMARY

It has been established that throughout the whole period of vegetation of kenaf phospholipids are present in all the organs, but in the stage of complete ripeness of the seeds they are localized mainly in the seeds. It has been shown that during the process of ripening of kenaf seeds the amount of total lipids in the seeds increases, which is accompanied by an increase in the amounts of PC, PE, N-acyl-PE, and N-acyllyso-PE and a decrease in PI. The intensive synthesis of unsaturated fatty acids in the phospholipids is observed in the period of the ripening of the seeds.

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