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INVESTIGATION OF THE DYNAMICS OF THE ACCUMULATION OF SOME SECONDARY METABOLITES OF COTTONPLANT LEAVES

A. M. Rashkes, N. K. Khidyrova, M. M. Kiktev, U. A. Abdullaev, and Kh. M. Shakhidoyatov

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The compositions of the secondary metabolites (SMs) of the leaves and petioles of cotton plants of the deciduous and selection lines L-275, L-470, L-475, and 142-F and the variety Tashkent-1 have been studied. It has been shown that the level of α-tocopherol and polyprenols in the leaf blades and petioles changes fairly sharply according to the phases of ontogenesis. The results of an exogenous treatment of the leaves of cotton plants of the control varieties Tashkent-1 and 108-F with the SMs showed an interrelationship of deciduousness and the quantitative composition of the sterols.

In the search for natural factors of ageing, the dynamics of the change in the level of free and bound sterols and triterpenols over the phases of ontogenesis in leaf blades and petioles of two deciduous selection lines L-275 and L-470 and the control variety Tashkent-1 (T-1) have previously been compared and investigated. The dynamics of the change in the level of free sterols (FS) in the leaf blades were different in the three lines but had an important feature — their maximum accumulation took place in an earlier phase in the deciduous lines than in T-1.

The characteristics found in the case of the sterols [1] induced us to investigate the levels of other SMs in the deciduous lines L-275, L-470, and L-475, and in T-1 by comparing the quantitative levels of tocopherols and polyprenols in four phases of ontogenesis, including the cotyledonous stage. In addition, it appeared of interest to compare the change in the levels of the SMs, especially the sterols, for the deciduous lines L-470 and L-475, and their donor 142-F. Figure 1*a* shows the dynamics of the change in the level of α-tocopherol in the leaf blades of T-1, L-470, and L-475. The maximum accumulation of tocopherol in the leaf blades of a deciduous line took place at an earlier stage, but the actual level of this compound in the leaf-shedding stage was higher than in the control variety. In the petioles (Fig. 1*b*) a substantial difference was observed between the lines; in particular, in T-1 the maximum took place at the maturation stage, while in L-475 there was a minimum in the same stage.

A study of the dynamics of the change in the level of undeca- and dodecaprenols, taken together, in the leaf blades and petioles of T-1, L-470, and L-475 (Fig. 2) showed that in the cotyledons the level of polyprenols was low, but in T-1 it was higher than in the deciduous lines. In all the lines, a first maximum was observed in the budding phase, and after this there was either a gradual fall in the level (T-1 and L-475) or an increase during the leaf-shedding phase (L-470). So far as concerns the petioles of the three lines, after passage through a maximum in the maturation stage there was a decrease to the leaf-shedding stage. The actual level of polyprenols in the petioles was an order of magnitude lower than in the leaf blades, while in the control, T-1, polyprenols were absent even in the budding stage.

Because of the difference existing in the biosynthesis of SMs in the deciduous line as compared with T-1, it appeared of interest to elucidate the possibility of the passage of a property of the donor into deciduous lines, such a donor being variety 142-F for L-470 and L-485. A comparison of the levels of SMs in 142-F, L-470, and L-475 in the maturation period showed a considerable decrease of all the monitored sterols in the leaf blades of the deciduous lines (Table 1). In view of the fact that in this stage there were more sterols in L-475 than in the control T-1, it may be concluded that the donor, 142-F, passes on to the deciduous line its genetic property of increasing the biosynthesis of sterols. The level of compounds of this class in the

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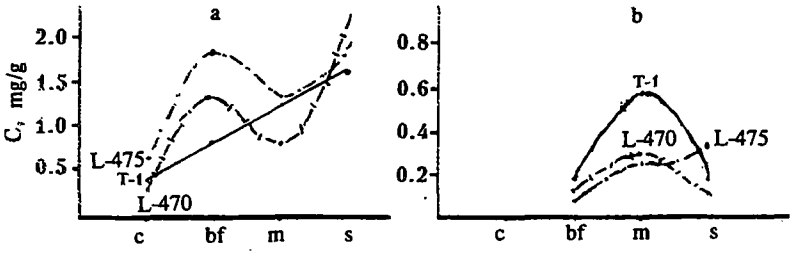

Fig. 1. Change in the level of α-tocopherol in leaf blades (*a*) and petioles (*b*). Here and in Fig. 2: c) cotyledonous stage; bf) budding–flowering; m) maturation; s) shedding.

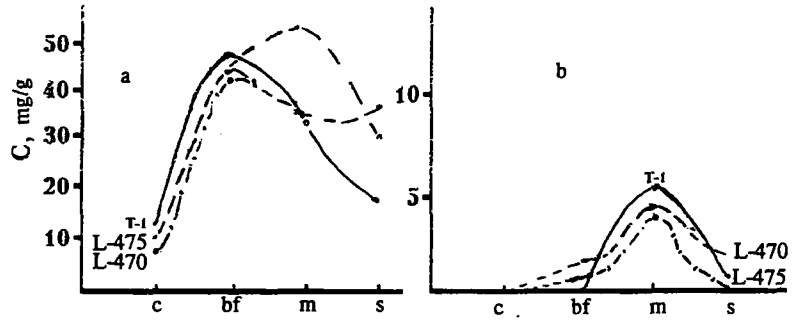

Fig. 2. Changes in the levels of polyprenols in leaf blades (*a*) and in petioles (*b*).

petioles of the deciduous line L-475 also occupied an intermediate position between 142-F and T-1 (Table 1), which permits the assumption of a transmission of the properties of the donor in this case, as well. The levels of other SMs such as α-tocopherol and amyrin in the leaf blades of the donor and the deciduous lines were of the same order, while in the petioles of the donor it was considerably lower than in the deciduous lines.

In all the deciduous lines the amount of polyprenols was lower than in 142-F (leaf blades), in which their level was very high, although there were no differences from T-1 in this phase. These facts enable us to judge the special role of polyprenols in defoliation. At the same time, the level of polyprenols in the petioles was not only small, even in a comparison of T-1 with the deciduous lines, but underwent a sharp change towards the moment of leaf-shedding. Thus, it is obvious that deciduousness is always connected with a fall in the level of polyprenols, but the fall in their level is not itself the cause of leaf-shedding.

The study of the levels of biologically active substances, especially α-tocopherol, in the various vegetation periods of the cotton plant is of theoretical interest in connection with the biosynthesis of α-tocopherol. Its presence in considerable amount in the cotyledonous stage has been shown previously, and this may indicate a pathway for the synthesis of α-tocopherol independent of that for chlorophyll. However, the facts mentioned do not unambiguously demonstrate this hypothesis, since the level of α-tocopherol in the cotyledons is 2-3 times less than in the period of maturity. It therefore appeared of interest to investigate the presence of α-tocopherol and of a number of other biologically active low-molecular-mass substances in plants containing no chlorophyll, so-called albinos.

U. K. Hadzhimov and A. Almatov (Tashkent State University, Biological Faculty) have obtained mutations in which the biosynthesis of chlorophyll is blocked — "Ksanta" albinos. In a study of the sum of their total extractive substances we detected an increased level of phytol — an unsaturated alcohol esterifying the porphyrin nucleus of chlorophyll during its biosynthesis. However, the level of α-tocopherol in the albinos (0.12% on the a.d.w.) was higher than in green plants (0.064% on the a.d.w.). It was considered that α-tocopherol accumulates in plants as a result of decomposition in the period of maturation and the liberation of phytol, while the amount of polyprenols and of plastoquinone decreases. This once again confirmed the independence of the synthesis of α-tocopherol from that of chlorophyll.

The correlations that have been established in the dynamics of the accumulation of SMs in the leaf blades and petioles of various lines of cotton plant under the action of exogenous treatment with defoliants [2] suggested a possible influence of these compounds on the leaf-shedding process. Small-plot field trials have been carried out using several groups of compounds

TABLE 1. Levels of α-Tocopherol, Amyrin, and Sterols in the Maturation Phase of Four Cottonplant Lines

Material	α-Tocopherol	β-Amyrin	β-Sitosterol	Stigmasterol	Cholesterol	24-Ethylidenecholesterol	Undecaprenol	Dodecaprenol
T-1								
Leaves	1.4	0.23	0.6	0.44	0.17	0.21	22.5	10.0
Petioles	0.6	0.15	0.71	0.34	0.195	0.107	4.2 -	0.9
L-470								
Leaves	0.8	0.17	0.62	0.26	0.13	0.11	24.23	3.15
Petioles	0.3	0.13	0.7	0.36	0.18	0.064	2.28	0.83
L-475								
Leaves	1.6	0.26	0.94	0.58	0.25	0.24	37.0	15.0
Petioles	0.21	0.04	0.22	0.12	0.063	0.28	1.1	0.32
142-F								
Leaves	3.85	0.2	0.81	0.49	0.19	0.27	49.0	21.0
Petioles	0.07	0.01	0.08	0.01	0.02	0.016	1.7	0.75

TABLE 2. Results of Three-Year Trials of Endogenous Compounds on the Leaf-Shedding Process

Preparations	Form of treatment	Dose, kg/ha	1991		1992		1993	
			T-1	108-F	T-1	108-F	T-1	108-F
Total	SL	0.125	60		63	53	53	57
sterols,	GP	0.04	52				50	49
SM-1	IM						50	53
Total L-475	SL	0.4	51		52	58	48	66
+ sitosterol,	GP	0.14	39			49	52	58
SM-3	IM							
Polyprenols,	SL	100	20	23				
SM-2	FSs[sic]	50	22	25				
Dropp	SL	0.6	71	23		43	47	36
	GP	0.2					43	31
	IM						53	36
OP	SL						24	
	GP						19	
Control			32	13	19	-	23	23

possibly affecting the ageing of cottonplant leaves. As such compounds we took the total FSs (SM-1), the polyprenols (SM-2), and the total extractives from L-475 (SM-3) in comparison with the preparation Dropp in doses of 0.25 kg/ha in each case. Exogenous treatment was carried out by three methods: 1) Deposition at the growing point (GP); 2) spraying a leaf (SL); and 3) the integrated method, i.e., simultaneous deposition at the GP and SL. The experiments were carried out over three years in an experimental field of the Biology Scientific Production Combine. The objects of investigation were the varieties T-1 and 108-F.

The results of the investigation (Table 2) show that exogenous treatment with the total sterols (SM-1) led to almost equal leaf falls for T-1 and 108-F at 50-60%. On treatment with L-475, the influence on variety 108-F was more pronounced (the percentage leaf fall was 66). On the basis of the results obtained it may be concluded that two fractions of SMs — namely, the total sterols and L-475 — obviously affect leaf shedding, which is of undoubted interest for creating ecologically pure technologies for the defoliation of the cotton plant. So far as concerns the polyprenols, they obviously do not affect leaf shedding, even though they take part in this process.

EXPERIMENTAL

Young and mature plants dried in the air were extracted as described in [1]. The combined materials SM-1, SM-2, and SM-3 were obtained as described in [3]. The levels of the SMs were determined by the mass-spectrometric method of multipeak monitoring [1, 4] on a MKh-1310 instrument.

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