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ALKALOIDS OF THE FLORA OF UZBEKISTAN, *Arundo donax*

V. U. Khuzhaev

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Alkaloids of Arundo donax *L. growing in four soil-climatic regions of Uzbekistan were studied. Twenty alkaloids including the new ones arundavine and arundafine were isolated from the plant alkaloids.*

Key words: *Arundo donax*, alkaloids, arundavine, arundafine.

The plant *Arundo donax* L. collected in Tadzhikistan has been previously studied [1]. We investigated the alkaloid composition of *A. donax* growing in four soil-climatic regions of Uzbekistan. We studied the aerial part, roots, rhizomes, and flowers in different vegetative periods of native and introduced species.

Total bases were isolated by extraction of air-dried material with ethanol or isopropanol and chloroform. Plants were treated preliminarily with dilute ammonia. It is noteworthy that $CHCl_3$ is more suitable because the smallest amount of emulsion is formed during treatment and isolation of the total bases.

It was found that the alkaloids are localized mainly in leaves, roots, and rhizomes.

Total bases were separated and pure alkaloids were isolated by column chromatography over Al_2O_3 and silica gel.

Table 1 shows the alkaloid composition of *A. donax* as a function of habitat during various vegetative periods. The total alkaloids differ both in quantity and composition of pure components, especially for native and introduced species. The highest alkaloid content was found during early growth (in both the aerial part and roots).

Donaxine has practical interest because it is the principal alkaloid of the total bases. It is found in introduced plants only in the aerial part. It is present only in traces or is sometimes absent in roots.

The qualitative composition of the total alkaloids of the cultivated species are almost the same. The content of pure components is of the same order of magnitude. Thus, arundine and donaxanine were isolated in minor amounts and arundinine was not observed in total bases from both.

The aerial part of the native plant from Fergana region also produces donaxine as the main alkaloid. Its content is maximal during early vegetation. The roots contain no donaxine.

Its content decreases as the plant grows. The new dimeric alkaloid arundanine [3] is found in small quantities in the total alkaloids of the aerial part during early vegetation but its content increases as the plant grows. Phenyl-β-naphthylamine, deoxyvasicinone, donine, arundine, donaxanine, donaxaridine, donaxarine, and donine were isolated by chromatography [4].

Total alkaloids of the subterrean parts (roots, rhizomes) contain no donaxine, donaxarine, donaxanine, deoxyvasicinone, phenyl-β-naphthylamine, donine, or donaxamine. The content of the principal alkaloid of this plant part, dimeric arundamine [5], is 16% (crude) of the total alkaloid mass. Arundinine is a dimeric alkaloid that appears in the total alkaloids of the roots only at the end of vegetation [6]. The roots contain mainly dimeric alkaloids (Table 1).

The main alkaloid in *A. donax* from Kashkadari region, like from Fergana region, is donaxine. The content of pure components is of the same order or magnitude. Thus, arundine and donaxanine in both specimens were isolated in minor amounts whereas arundinine was not observed. Native plants from Kashkadari and Fergana valleys are much richer in alkaloids both quantitatively and qualitatively than introduced species and can provide a source of donaxine because its content is 0.14 and 0.12%, respectively, of the air-dried plant mass.

Donaxine hydrochloride was prepared previously from *A. donax* growing in difficultly accessible regions of Tadzhikistan. Now we have found a new source in Uzbekistan.

S. Yu. Yunusov Institute of the Chemistry of Plant Substances, Academy of Sciences of the Republic of Uzbekistan, Tashkent, fax (99871) 120 64 75 and Kokand State Pedagogic Institute, Kokand, ul. Istambul, 23. Translated from Khimiya Prirodnykh Soedinenii, No. 2, pp. 136-138, March-April, 2004. Original article submitted January 19, 2004.

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TABLE 1. Alkaloids Isolated from *A. donax* from Four Habitats

Plant organ	Vegetative period	Alkaloid
		Introduced in Tashkent
Aerial part	Start of vegetation	Donaxine, phenyl-β-naphthylamine, deoxyvasicinone, arundine, ardine, donaxarine, donaxanine, donaxaridine, donine
		Introduced in Samarkand
Aerial part	Start of vegetation	Donaxine, phenyl-β-naphthylamine, deoxyvasicinone, arundine, ardine, donaxarine, donaxanine, donaxaridine, donine
		Kashkadari region
Aerial part	Start of vegetation	Donaxine, phenyl-β-naphthylamine, deoxyvasicinone, arundine, ardine, donaxarine, donaxanine, donaxaridine, donine, arundinine
		Fergana region
Aerial part	Start of growth	Donaxine, donaxanine, donaxaridine, deoxyvasicinone, arundine, ardine, donaxarine
Roots	Start of growth	Arundamine, arundanine, arundacine, N-methyltetrahydro-β-carboline, arundarine, arundavine, arundafine
Aerial part	Fast growth	Donaxine, phenyl-β-naphthylamine, deoxyvasicinone, arundine, ardine, donaxarine, donaxanine, donaxaridine, donine, arundinine, bufotenine, donaxamine
Roots	Fast growth	Donaxine N-oxide, arundamine, arundanine, arundacine
Roots and rhizomes	End of vegetation	Arundamine, donaxin N-oxide, arundinine, arundanine, arundacine
Flowers	Flowering	Donaxine, donaxaridine, arundinine

TABLE 2. Alkaloids Isolated from *A. donax* Growing in Uzbekistan

Alkaloid	Composition	mp, °C
Donaxine	$C_{11}H_{14}N_2$	134-135
Deoxyvasicinone	$C_{11}H_{10}N_2$	110-112
Donaxine N-oxide	$C_{11}H_{14}N_2O$	135-136
Phenyl-β-naphthylamine	$C_{16}H_{13}N$	109-110
Bufotenine	$C_{12}H_{16}N_2O$	Amorph.
N-Methyltetrahydro-β-carboline	$C_{12}H_{14}N_2$	216-218
Donaxaridine	$C_{11}H_{14}N_2O_2$	178-180
Donaxarine	$C_{13}H_{16}N_2O_2$	218-220
Donaxanine	$C_{12}H_{14}N_2O_2$	162-164
Donaxamine	$C_{10}H_{12}N_2$	178-179
Arundine	$C_{17}H_{14}N_2$	165-166
Ardine	$C_{18}H_{16}N_2$	Amorph.
Donine	$C_{19}H_{22}N_2O_4$	126-128
Arundinine	$C_{23}H_{28}N_4O$	148-149
Arundamine	$C_{23}H_{28}N_4O$	104-105
Arundanine	$C_{24}H_{30}N_4O$	198-199
Arundacine	$C_{25}H_{30}N_4O_2$	192-193
Arundarine	$C_{24}H_{28}N_4O_2$	230-232
Arundavine	$C_{23}H_{28}N_4O_2$	250-252
Arundafine		205-207

Thus, twenty bases were isolated from introduced and native plants growing under natural conditions in four habitats as a result of the study of the quantitative and qualitative compositions of *A. donax* alkaloids (Table 2).

A new type of dimeric indole alkaloids, arundamine, arundanine, and arundacine [4-7], and the new alkaloids arundavine and arundafine in addition to known bases were isolated by chromatography of the polar fraction from the weakly basic fractions of total alkaloids from roots collected at the start of growth.

Arundavine, $C_{23}H_{28}N_4O_2$, exhibits an IR spectrum with absorption bands of active H (3245 cm^{-1}), an aromatic ring (1606, 1510 cm^{-1}), stretching and deformation vibrations of CH–, CH_2–, and CH_3– (2882, 1463, 1385 cm^{-1}), and an ether (1001, 950 cm^{-1}).

The molecular weight of arundavine was confirmed by a peak for the molecular ion with *m*/*z* 392 in the mass spectrum. The spectrum contains peaks for fragments with *m*/*z* 375 (98%), 347, 334, 288, 273, 173, 145, 95, 57 (100%) that confirm the indolic nature of arundavine.

Arundafine has an IR spectrum with absorption bands of active H (3320 cm^{-1}) and an aromatic ring (1610, 1520 cm^{-1}).

The mass spectrum of arundafine has a peak for the molecular ion with *m*/*z* 390 and fragments with *m*/*z* 372, 332, 297 (296, 295), 237, 170, 145, 130, 92, 81, etc.

Spectral data and the high molecular weight are consistent with the dimeric nature of the alkaloids.

EXPERIMENTAL

Total alkaloids were isolated by the literature method [8].

Ground roots of *A. donax* (6 kg) collected in April 2002 in Fergana region were extracted with $CHCl_3$ to afford total alkaloids (24 g, 0.4% of the air-dried plant mass) (18 g soluble in $CHCl_3$ and 6 g soluble in butanol).

Arundavine. The $CHCl_3$ fraction of bases (18 g) was chromatographed over an Al_2O_3 column with elution by $CHCl_3$. Six fractions (6 × 150 mL) were collected. The second fraction was rechromatographed over a silica-gel column with elution by $CHCl_3$. Thirty fractions were collected (30 × 5 mL). Fractions 6-30 were combined and again chromatographed over an Al_2O_3 column with elution by benzene to give 25 fractions (25 × 5 mL). Fractions 3-15 were combined and produced crystals (35 mg), mp 250-252°C, R_f 0.25 (benzene).

Arundafine. Fractions 15-25 were combined. Crystals formed, mp 205-207°C (20 mg), R_f 0.25 (TLC, Al_2O_3, $CHCl_3$:CH_3OH, 2:1).

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