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MORPHO-ANATOMICAL ADAPTATIONS OF LEAVES IN ROADSIDE PLANTS NEAR THE E-5 HIGHWAY

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ABSTRACT. In this paper the results of the studies on the influence of traffic density on leaves of roadside plants near highway E-5 are presented. These investigations were made by morphological and anatomical methods. All plants were collected in the close vicinity of traffic lines, maximum distance 3m, along the highway E-5, on the section Batočina – Smederevo. Morfo-anatomical studies of leaves from the investigations localities included leaves thickness, cuticle and palisade thickness, size of epidermal cells and ventilation of leaf spongi tissue. All results we compared them to condition of plants growing on unpollution terrains, along a cart track with little traffic in the Bešnjaja, near Kragujevac. The results show that, in relation to ones from unpolluted terrains, plants near highway exhibit a whole series of adaptations in morfo- anatomical structure of the leaves.

INTRODUCTION

The environment today is exposed to many different kinds of pollution. Among the more significant polluters are all forms of transportation. With the enormous number of motor vehicles constantly emitting exhaust fumes into the atmosphere, road traffic has a special place in pollution of the environment. Motor vehicles send to atmosphere large quantities of CO_2, CO, SO_2, H_2SO_4, H_2S, various hydrocarbons, ammonium, dust etc (Wheeler et all., 1979; Warren at all., 1987).

The greatest incidence of transportation-induced pollution occurs near highways and other busy thoroughfares with high traffic density. Atmospheric and soil pollution is most severe within a few meters from the roadway, beyond which zone it declines (Garcia et all., 1996; Scalon, 1991; Ylaranta, 1994).

Transportation-induced atmospheric pollution exerts both immediate and cumulative influence on the forms of life existing near roads, above all affecting plants as primary producers. This influence on plants is also on the increase due to the fact that pollutants accumulate in the roadside soil, from which plants are supplied with the water and minerals needed for the process of photosynthesis.

As part of Project S.5.32.65.0066, we investigated the influence of traffic on morpho-anatomical characteristics of leaves in plants growing beside the E-5 highway on sector Batočina – Smederevo. The purpose of the present work was to determine the influence on plant leaves exerted by harmful substances from automobile exhaust emissions on a sector of the E-5 highway with great traffic density by monitoring leaf morpho-anatomical adaptations, and then to compare these results with the same parameters in plants along unpolluted terrains (beside a cart track).

MATERIAL AND METHODS

Investigations were conducted on sector Batočina – Smederevo of the E-5 highway, a heavily traveled modern four-lane toll road, in June and July of 1998 and 1999. Plant material in the final phase of ontogenesis was collected in the immediate proximity of the road at a distance of not more than 3 m away from it over the entire length of the sector. The sites of sample taking were 5 km apart from each other on one side of the road and between these places on the other side. Leaves were collected from different plant species (100 specimens from different individuals of the same species) and the collection sites recorded over the entire sector. The control consisted of leaves collected at the same time and under similar conditions from the identical plant species in the same stage of ontogenesis along a cart track with little traffic in the Besnjaja natural area near the city of Kragujevac. The analysing of the morpho- anatomical characteristics of leaves was done by make long term preparations of cross section of leaves and by measuring. The results are shown in tables.

RESULTS AND DISCUSSION

Roadside plants occupy a special living niche and represent a specific group of plants exposed by reason of openness of the terrain to particular ecological factors such as increased insolation, strong winds, etc. The factor of different traffic density further complicates the situation by creating ecological conditions under which these plants are exposed to immediate and cumulative action of toxic and harmful substances entering the atmosphere with the exhaust fumes of motor vehicles. All of this gives rise to an increase of structural xeromorphism in plants from these terrains.

Anatomical analysis of leaves showed that differences exist in the extent of development of certain tissues in plants from the investigated terrains. Measuring and comparing of leaf thickness in cross section, cuticle thickness, thickness of the palisade tissue, and size of epidermal cells revealed the existence differences.

Comparison of leaf thickness in cross section reveals the existence of differences between plants from the investigated terrains (Tab. 1). Plants along the E-5 highway have the thicker leaves, those beside the cart track have the thinner leaves. This relationship exists in all of the investigations plant species.

By the same procedure of comparing leaf cross sections, it was established that plants along the E-5 highway have the thicker cuticle, those beside the cart track have the thinner cuticle (Tab. 1).

Analysis of leaf cross sections also established that plants along the E-5 highway have the thicker palisade tissue, those beside the cart track have the thinner palisade tissue (Tab. 1).

Comparison of the size of epidermal cells on cross sections reveals the existence of differences between plants from the investigated terrains. Plants along the E-5 highway have the smaller epidermal cells, those beside cart track have the larger epidermal cells (Tab. 1).

Ventilation of leaf spongy tissue indicates the intensity of gas exchange with the external environment. Plants resistant to air pollution as a rule have poorer ventilation of the spongy tissue, i.e., fewer intercellular spaces, in their leaf structure. Analysis of the anatomical structure of leaves in plants along the E-5 highway indicated that all of the studied plant species there have this trait in pronounced form. The same plants collected along the unpolluted cart track have better ventilation, i.e., larger and more numerous intercellular spaces, in the spongy tissue. This trait is closely linked with the number, size and opening of stomata (Topuzovic and Banković, 1998) as well as with physiological processes of photosynthesis and respiration. In work Topuzovic and Banković (1998), the results showed that through a large number of small stomata, plants defend themselves against excessive transpiration and regulate the intake of gases from a polluted atmosphere. This anatomical adaptation, in conjunction with brief and infrequent stoma opening during the day, reduces to a minimum the intake of toxic fumes and heavy metals into the plant organism, while still maintaining a level of aeration sufficient for performance of the basic vital processes.

In plants from polluted terrains along the E-5 highway, the basic vital processes are reduced to the minimum capable of ensuring survival and development, the intake of toxic components from the atmosphere being likewise reduced to a minimum.

CONCLUSION

The results obtained in studying the morpho-anatomical structure of leaves in roadside plants highly polluted by traffic on the E-5 highway, monitoring their life cycle, and comparing the findings with plants along an unpolluted cart track enable us to draw certain conclusions about structural adaptations in the investigated plants.

In relation to ones from unpolluted terrains, plants exposed to the constant action of traffic-induced pollution exhibit a whole series of adaptations in morpho-anatomical structure of the leaves. They have thicker leaves, thicker cuticle, thicker palisade tissue, larger epidermal cells, fewer intercellular spaces in the spongy tissue, and smaller and more numerous stomata. All of the listed traits dictate slower development and later maturation of the plants, since they lead to a lower level of organic production.

The capacity for adaptation to a polluted environment in plants along the four-lane highway is demonstrated precisely by the fact that despite slowing of their development, they attain and pass through all phases of ontogenesis and continue to colonize an exceptionally unfavorable habitat exposed to constant pollution from traffic.

Optimal conditions on the compared unpolluted terrains along a cart track cause the same plant species to undergo more extensive and faster development. Their leaves are thinner and have thinner cuticle, larger and fewer stomata, and more intercellular spaces in the spongy tissue. They perform photosynthesis more intensively and attain all phases of development faster.

Tab.1. Comparative analysis of anatomical characteristics of leaves some roadside plant species (in μ). – H-highway, C- control

Plant species	Localities	Leaves thickness			Cuticle thicknes			Height of epid. cells			Width of epider. cells			Palisade thickness		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Cichorium	H	177	207	193.5	1.9	5.4	3.6	8.2	13.8	11.7	16.9	26.4	21.6	61	79	70
Inthybus	C	178	207	194.6	1.7	5.3	3.2	8.3	13.9	12.0	17.2	26.4	22.3	59	75	68
Rosa	H	190	215	201.8	4.8	8.0	5.9	7.8	12.6	10.1	13.5	22.7	18.5	67	87	75
canina	C	192	217	203.8	4.0	7.2	5.2	8.7	13.6	11.1	14.9	23.4	19.4	64	85	72
Stenactus	H	183	208	195.1	2.0	5.2	3.5	8.3	13.6	10.2	23.0	29.0	26.8	79	127	99
annua	C	187	213	197.6	1.7	5.0	2.9	9.0	14.5	11.2	26.0	30.0	28.2	76	119	96
Rubus	H	137	174	159.4	1.2	5.4	3.1	3.0	9.0	6.9	18.0	30.0	24.2	58	77	68
caesius	C	142	175	162.1	0.9	5.2	2.9	3.6	9.4	7.2	18.8	32.0	25.4	55	74	65
Plantago	H	215	250	235.8	1.8	5.2	3.6	12.0	17.2	14.8	19.4	34.0	26.3	57	70	65
lanceolata	C	222	253	237.6	1.5	4.8	3.1	13.0	17.6	15.4	21.0	35.0	27.3	54	67	60
Amarantus	H	183	200	191.7	4.3	5.5	5.1	9.2	15.5	12.6	19.8	29.7	25.6	78	125	97
retroflexus	C	186	205	193.6	4.3	5.4	5.0	9.6	16.0	13.0	21.5	30.4	26.3	76	121	94
Artemisia	H	92	109	102.5	2.6	4.1	3.2	7.5	12.8	9.9	9.0	16.5	12.8	35	47	42
vulgaris	C	96	112	104.9	2.4	3.7	3.0	8.0	13.0	10.3	9.9	17.5	13.6	34	45	40
Urtica	H	130	148	138.2	1.0	5.3	2.9	8.3	11.2	9.9	16.5	26.4	21.1	40	50	45
dioica	C	133	148	140.2	1.2	5.0	2.7	8.8	12.4	10.4	17.0	28.1	21.8	38	50	43
Juglans	H	224	255	238.9	4.4	5.5	5.2	9.5	11.5	10.6	19.0	26.0	21.9	90	112	99
regia	C	225	256	241.6	4.0	5.4	5.0	9.8	12.4	11.3	20.0	26.0	22.9	88	108	97

Tab. 1. Continue

Galium	H	165	210	181.5	3.3	8.6	5.9	6.6	9.9	8.2	9.9	19.8	15.3	57	86	74
verum	C	170	205	184.2	3.3	8.3	5.5	6.6	10.6	8.8	11.5	21.5	16.0	55	83	72
Cirsium	H	140	380	301.1	3.9	11.6	6.6	8.3	16.5	11.6	19.8	34.7	26.5	80	150	115
arvense	C	145	390	303.5	3.9	10.6	6.3	8.3	17.5	12.1	21.0	36.0	27.3	78	140	112
Hyperricum	H	194	212	202.2	4.0	7.4	5.1	9.4	19.5	14.1	25.8	37.0	32.5	69	110	96
perforatum	C	196	212	203.9	3.4	7.3	4.9	9.9	20.5	14.6	27.0	38.0	33.3	67	109	94
Rumex	H	174	207	194.6	2.0	7.1	4.5	8.2	12.4	9.9	18.0	23.8	20.2	66	99	82
crispus	C	176	207	196.9	1.6	6.8	4.4	8.3	13.0	10.4	18.4	24.0	20.8	65	97	80
Poa	H	136	154	146.8	1.5	3.6	2.4	5.0	6.4	5.7	7.0	16.0	10.8	-		
annua	C	137	156	148.3	1.3	3.4	2.2	5.4	6.7	6.1	7.2	17.0	11.5			
Cynodon	H	133	159	146.9	1.6	3.8	2.7	5.2	6.4	5.8	8.0	13.0	10.8	-		
dactylon	C	134	159	148.7	1.5	3.7	2.6	5.4	6.6	6.2	8.5	14.0	11.4			
Robinia	H	134	154	145.5	1.3	3.3	2.4	4.6	6.2	5.4	6.4	16.0	11.1	54	74	65
pseudoacaci	C	136	155	147.3	1.2	3.2	2.2	4.8	6.5	5.8	7.0	17.5	11.9	54	72	63
Sambucus	H	155	225	191.5	1.9	5.5	3.6	8.7	12.5	10.9	22.2	26.4	24.4	61	89	77
ebulus	C	157	228	193.6	1.7	5.3	3.3	9.2	13.0	11.3	23.5	26.6	25.4	61	86	75
Vicia	H	99	135	119.3	1.4	3.0	2.4	7.0	12.0	9.0	16.0	20.0	18.5	47	67	57
craca	C	102	137	120.9	1.2	2.8	2.2	8.0	12.5	9.5	17.0	20.5	19.3	45	65	55
Senecio	H	140	170	152.1	3.3	6.0	4.6	6.8	13.5	8.5	12.0	18.0	15.0	56	77	67
vulgaris	C	141	172	154.0	3.2	6.0	4.4	7.0	14.6	9.0	13.0	19.0	16.1	56	75	66

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