

THE IMPLEMENTING OF SOME PLANT SPECIES IN EROSION CONTROL ON SLOPES

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Abstract - With the need to conserve and improve the environment, it is recommended to employ plant materials in the erosion control of torrents and slopes alongside roads. Considering the well-known properties of some willow species regarding their power of vegetative reproduction, survival in poor soils and often flooded alluvium, we researched into the potentials of the following species: *Salix triandra* L., *Salix purpurea* L. and *Salix incana* Schrk. in the catchment of the warehouse "Gvozdac", Experimental Estate Goč, Serbia.

The research started in 2004 and has continued till the present day. The above-mentioned willow species showed significant efficiency in the bank protection of torrential watercourses and on the moist slopes of embankments and cuts of roads. Some of them can even stand a certain degree of aridity, while other species, on poor, eroded soil exposed to long and extreme drought, could not survive and did not show the expected effect, which is also the consequence of the absence of maintenance and adequate attention to such erosion-control works.

In spite of the above, one of the willow species survived even in the most severe conditions, checking the erosion of the road cut slope and the road construction itself, and prevented the impacts of aggressive atmospheric waters, thus halting the erosion ridges and the removal of the asphalt road surface.

The above facts prove that, with adequate measures of maintenance, plant materials can be very successfully applied for both longitudinal structures and to check dams in torrent control, as well as in erosion control on the slopes in catchments, both in civil engineering works and in forest exploitation.

The research requires closer attention, extending the interests to some grass and shrub species, with the aim of ecological erosion control and reclamation of endangered watercourses, slopes and, in general, environmental protection and nature conservation.

Keywords: Erosion control materials, ecology, willow species, river erosion, anthropogenic erosion, road protection.

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INTRODUCTION

Willow is the pioneer species in wet terrains, and is an ideal solution for the reclamation of the eroded slopes of hilly and mountain watercourses and of road cuts and fills in such regions. Research of this topic has been carried out since 2004 in the catchment of the warehouse Gvozdac, on the Experimental Estate of the Faculty of Forestry in Belgrade.

MATERIALS AND METHODS

This study deals with species of willow *Salix triandra* L., *Salix incana* Schrk, and *Salix purpurea* L. In the

autumn of 2004, cuttings of *Salix triandra* L. were planted in lines on the eroded right bank of the Gvozdačka river and on the cut of the road Dobre Vode – Studentsko Naselje Gvozdac. In the following autumn, rooted cuttings of *Salix incana* were also planted in lines at the above two localities and on the cut of the road Studentsko Naselje – Brezna.

In October 2007 the success of the application of the above species was tested. By field monitoring, it was concluded that *Salix triandra* advanced favourably on the banks of the Gvozdačka river with a success rate of up to 90%. However it did not survive on the slopes along the roads: it was either suppressed

by other herbaceous and shrubby vegetation, or the ground remained bare on the serpentine slope on the right side of the road Studentsko Naselje – Brezna, on its southwest, dry side.

Starting from the need to conserve and improve the environment, such an application of plant material in erosion control has a great significance.

Taking into account the well-known properties of some willows regarding their vegetative propagation and survival on poor and frequently flooded river sediment, we also started the study of *Salix purpurea* L. applicability on the lands of the Experimental Estate Goč.

The study started in the autumn of 2004. The cuttings of *Salix triandra*, were taken from the surroundings of Kraljevo, from the banks of the rivers Ibar and Zapadna Morava, and planted on eroded banks of the Gvozdačka river, the Experimental Estate “Goč” of the Faculty of Forestry, where they thrived successfully. In October 2007 they attained an average height of 2.05 m and a diameter of about 1 cm.

The *Salix incana* cuttings were taken from Pešter, in the autumn of 2005 and planted along the eroded banks of the river on Mt. Goč – Gvozdac, where on the 10th of October 2007 their average height was 0.79 m and diameter 0.6 cm.

In October 2007, the cuttings of these two willow species were planted at the places endangered by erosion, on road cuts and along the eroded banks of the Gvozdačka river.

In October 2008 *Salix purpurea* L cuttings were also planted. They were taken from the Nursery of the Institute of Forestry. This species was included in the study based on previous plant community research, and the well-known properties of the species.

It occurs on the alluviums of minor rivers as an ephemeral plant community. It was found near White Drim, Drina, Toplica, Pek and its tributaries. This plant community with sometimes open canopy occurs along the rivers with abundant sun-

light. The preferable soils are poorly developed and shallow. The ground surface is usually covered with sand, with 7-27 % of clay, on the top of densely compacted gravel with layers of sand. The area of the profile is about 70 cm from the river level. The soil is heterogeneous and not structural, with an interrupted capillary rise of groundwater, so it has very contrasting moisture content. This shows that red osier is a species of high ecological amplitude. It survives even on the terrains unsuitable for other willows. If it grows on better soils, it can be suppressed by other species. It grows in the community with *Populus nigra*, to which it is ecologically closer, with dry soil of lighter texture, than the almond-leaved willow, which is closer to white willow. As a pioneer species it lives on heterogeneous and less favourable sites, coarse sand and gravel sites. In Serbia, there are several subassociations of this plant community. Red osier occupies positions near river water, so it is a plant community which requires more moisture than gray willow, but frequently because of erosion - alluvial processes, it transits into more complex, higher communities or into lower, herbaceous communities.

The almond-leaved willow, *Salix triandra* L., grows on alluviums as its pioneer community, near the rivers Zapadna Morava and Velika Morava, Sava, Tisa, Danube and other rivers.

It occupies the lowest parts of the reefs and fringes of open and closed depressions where water stays for the longest period, so its sites are under water for a long time and always with a high level of groundwater and moist capillary clay soils. The profile consists of: clay and sandy-clay loam, and the groundwater level is high (about 0.95 m). Its texture is loamy-sand and sandy-clay loam, of lighter texture, weak alkaline reaction, with 2-8% of humus. According to Pavičević *et al.*, they are calcareous waterlogged alluviums. This species is regularly accompanied by *Salix alba*, then *Populus nigra* and *Salix fragilis*. The ground layer is floristically poor, which is a consequence of waterlogged ground and the domination of the almond-leaved willow.

In Serbia the plant community of almond-leaved willow differs from other communities in more northern regions, by the differential species, e.g. the absence of *Salix viminalis*. According to Moor (1958), the plant community of almond-leaved willow is the border, shrubby plant community of *Salicetum albae*. When by the deposition of river sand, the level of the ground rises, almond-leaved willow is replaced by white willow, which invades the space.

Salix incana Schrnk (*Salix eleagnos* Scop.) grows on serpentinite. It is a basiphilous species and by its horizontal and vertical range it is a hilly-submontane sub-Mediterranean species (Oberdorfer, 1962) so it grows in our south and higher lands.

Gray willow plant communities occur on gravel and coarse sand, making them similar to the conditions of the community with red osier. It occurs along rapid hilly and mountain rivers, flooding the surrounding land for a longer time and has a great erosion power. Plant communities of gray willow have an important role in the fixing of banks and deposited coarse materials. On such sites, it is endangered during the summer when water is low and when it has insufficient moisture. The xeromorphic structure of gray willow leaves (very narrow, hairy with a strong cuticle) indicates its adaptation to contrasting sites regarding moisture content. Jurko (1964) reports that gray willow has a "deep vertical root system". Such a system supplies plant moisture when the water is low, and plant stability when the water level is high. The soil reaction is alkaline – pH above 8. It is a basiphilous species, growing on coarse gravelly-sandy alluvium. Numerous stands occur on serpentine lands. Its demand of air in the soil is high, because it grows in the upper courses with rapid water and with a coarser sediment. This is the factor which defines many species on moist alluviums.

Some species in the ground layer indicate that in the period of vegetation growth, in the gray willow community there is no effect of groundwater and capillary water in the upper soil layers.

Owing to the above facts, it can be seen that almond-leaved willow grows nearest to stream water, followed by red osier and finally gray willow, which tolerates even temporary droughts.

In October 2007, 2 to 3-year-old rooted cuttings of *Salix triandra* and *Salix incana* were planted at previously marked places endangered by erosion, along the mountain road.

The cuttings of almond-leaved willow and gray willow were planted in lines along the contour on eroded scarps, in the stretch Studentsko Naselje - Dobre Vode, on shady slopes of southwest exposure, and from the dam "Gvozdac" towards Brezna on the serpentic bedrock of southwest exposure.

According to literature, *Salix purpurea* L. (Jovanović B., 1967) is resistant to climate extremes. It grows on gravel and sand, most often along river banks. According to its biological properties, it is suitable for hedges and for fixing the sediment and river banks, because it can tolerate some drought, like *Salix eleagnos*, and according to the "Flora of Serbia", it thrives beside rivers and brooks on coarse sandy-gravelly sediment and in forests of willow and poplar. Its range (Prodromus) is like *Salicetum purpureae* Mend-J. 1958, subass. *Myricaretosum* Jov. 65, along the Beli Drim river, subass. *Incanetosum* Jov. 65, along the Rzav river, subass. *Alnetosun glutinosae* Jov. 65, along the Toplica river (Jovanović B., Tucović A. 1965), and it grows at the altitude up to 1800 m, where it is a shrub 4-10 m high (according to the Forestry Encyclopaedia).

Salix eleagnos Scop. (*Salix incana* Schrk.) is a shrub or a tree up to 10 m high. It grows even in subalpine regions and it is frequent in West Serbia on serpentic bedrock. It can tolerate occasional droughts and it is an obligatory heliophyte. It is a pioneer community (Flora of Serbia) *Salicetum incana* Jov. et. Tuc., near rapid hill and mountain rivers, on coarse sediments of contrasting moisture regimes. In improved soil conditions, it ranges into *Alnetum incanae*, and it is distributed in Serbia near the rivers Pečka and Dečanska Bistrica, Beli Drim, Lim, Mileševska Reka, Ibar, Toplica, Đetina, Rzav,

Drina etc. and very frequently near watercourses in West Serbia. According to the Prodromus of *Salicetum incana* Jov. et. Tuc. 1965, it occurs along the rivers Ibar, Toplica, Đetina and Drim, and according to Jovanović B. Tucović, A., (1965) and the Forestry Encyclopaedia, *Salicetum eleagnos* Moor 58 is a pioneer community near the rivers Lim, Mileševska Reka, Ibar, Toplica, Đetinja, Drina, etc.

RESULTS AND DISCUSSION

In October 2007, three-year-old rooted cuttings of *Salix triandra* L. along the banks of the Gvozdča river attained an average height 2.02 m and diameter of about 1 cm. They fixed the right bank in the river curve quite efficiently.

The seedlings of the same species on the road cut and on the serpentinic bedrock, southwest exposure, had a lower growth, poor survival (about 10%), vitality and efficiency, because they were on dry and shallow soil and the measures of tending and maintenance were absent. Also, we recorded a poor state of this species in the shallow acid brown soil on the cut of the road Studentsko Naselje – Dobre Vode.

In the same period, the two-year-old rooted cuttings of *Salix incana* Schrk., fixed the eroded bank of the Gvozdča river efficiently. Their average height was about 0.80 m, diameter about 0.6 cm. About 50% of the rooted cuttings survived on the serpentine cut of the road. Their height was

lower and their diameter smaller: there were no tending operations. About 70% of the rooted cuttings survived on the cut of the Dobre Vode road. They thrived quite well but less so than those along the river bank.

The following diagram represents the height curve of two-year-old *Salix incana* Schrk. on the eroded bank of the Gvozdča river.

In early spring of 2008, one-year-old rooted cuttings of *Salix purpurea* L. were planted on two road cuts because this species tolerates a contrasting moisture regime, as well as shallow and undeveloped soils and great ecological amplitudes.

By field monitoring, in spring 2009 it was assessed that *Salix triandra* L. had survived and performed its erosion control function only along the banks of the Gvozdča river, because it is a species which requires sufficient moisture. It was not successful at the other two sites, because there were no tending operations and maintenance, i.e. it was in unfavourable natural conditions of shallow and dry soil, warm exposure with very high summer temperatures and low precipitation in the dry year of 2007.

After three and four years, *Salix purpurea* L. also showed poor results in the erosion control of road slopes because tending measures were absent, and it was threatened by high temperatures and summer drought in 2007. The plants did not survive.

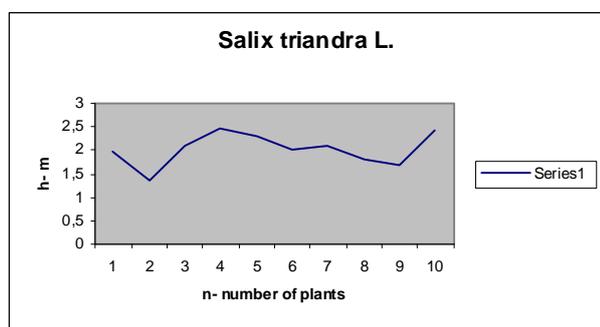


Diagram 1. n - number of representative rooted cuttings; h – height of rooted cuttings

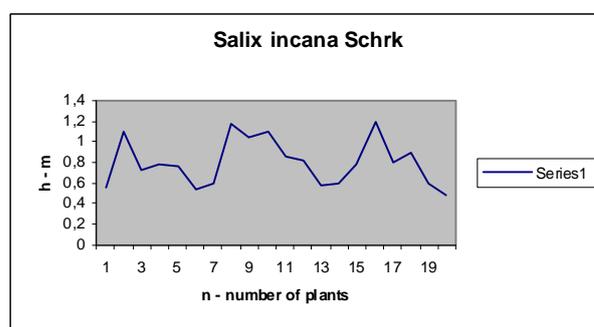


Diagram 2. n - number of representative rooted cuttings; h – height of rooted cuttings (m)

Salix incana Schrk showed some positive results in the reclamation of road slopes. It survived at the site Dobre Vode, preventing water erosion of road slopes and road surfaces at the places where it survived in a low percentage (about 10%).

Although the above results are not very satisfactory, if we take into account the absence of tending operations and the difficult climate conditions, it can be concluded that *Salix triandra* and *Salix purpurea* showed satisfactory results in fixing the banks of mountain rivers. Their efficiency was considerably poorer in the reclamation of shallow and dry slopes further away from the river. *Salix incana* showed encouraging results on the eroded slope of the Dobre Vode road, where it survived and fixed the eroded ground, preventing surface and line erosion.

CONCLUSION

The experiments were carried out in natural, difficult conditions, mountain climate, drought, and absence of tending and human intervention. It is presumed that in the case of better tending, the results would be much better, and that the percentage of survived plants would be considerably higher, which confirms the hypothesis that some species in the genus *Salix* L. can be used in erosion control of mountainous watercourses and road slopes in mountainous and hilly regions. If soil conditions, climate, exposure, moisture and, in particular, tending operations and maintenance of the material are paid attention to, *Salix triandra* can be recommended for fixing the alluvium and for the regulation of stream banks. *Salix purpurea* L., as the pioneer light-demanding species, can reclaim even occasionally dry soils, of lighter texture, and thereby preparing the ground for more complex, higher communities. *Salix incana* Schrk., as a submontane, sub-Mediterranean species, can bind the banks and sediment of rapid mountain watercourses as well as slopes with contrasting moisture regimes, because strong vertical root system firmly binds the basic

substrates. It requires a sufficient ratio of air in the soil, so it is recommended for the binding of the serpentine ground of the upper courses with coarse structure. It tolerates moderate drought, which resulted in the suppression of erosion of the above mentioned cut. In all cases, the willow rooted cuttings had a greater success and faster growth than other cuttings.

The study produced encouraging results in the application of plant material in erosion control. However, this study requires further experiments with other shrubby and woody species in the suppression of soil erosion, aiming at the conservation of the natural environment, its enhancement and enrichment with new, beneficial species, instead of the exclusive implementation of structural materials, whose significance is not questioned by this study in the cases of the more aggressive action of erosion agents, especially if water velocity is greater than 2-2.5 m/sec.

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ПРИМЕНА НЕКИХ БИЉНИХ ВРСТА ЗА ПРОТИВЕРОЗИОНУ ЗАШТИТУ КОСИНА

ВЈАЧЕСЛАВА МАТИЋ

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Полазећи од потребе очувања и унапређења животне средине и природе, уопште, јавља се идеја о примени биљног материјала за противерозиону заштиту бујичних водотока и косина, дуж саобраћајница. Уважавајући позната својства неких врста врба у вези са моћи вегетативног размножавања, способности опстанка на сиромашном и често плављеном алувијуму, вршено је и траје истраживање о могућностима употребе врста: *Salix triandra* L., *Salix purpurea* L. и *Salix incana* Schrk. у сливу акумулације “Гвоздац”, на Гочу.

Истраживања су започета 2004. године, а трају и даље на наведеном локалитету.

Поменуте врсте врба су показале значајну ефикасност код заштите обала бујичних водотока и влажнијих косина насипа и усека саобраћајница, неке од њих чак подносећи и извесну сушу, док се неке, на сиромашном, еродираним супстрату и изложене дужој, екстремној суши и инсолацији нису одржале и показале очекивани ефекат, што је и последица недостатка неге и

потребне пажње за овакве противерозионе радове.

Упркос свему једна од наведених врста врба је успела да опстане чак и у тако суровим условима, заустављајући ерозију шкарпе усека пута и саме путне конструкције од деловања агресивних атмосферских вода, спречавајући тако ерозионо браздање шкарпе и одношење асфалтне подлоге саобраћајнице.

Наведен је доказ да се уз нужне мере неге и пажње, фитоматеријал може врло успешно користити за подужне и попречне бујичарске објекте, као и за противерозиону заштиту косина у сливу и при извођењу грађевинских радова и експлоатацији шума.

Истраживања захтевају значајнију пажњу и проширивање интересовања и на неке друге травне и жбунасте врсте, у циљу еколошке противерозионе заштите и санације угрожених водотока, косина и уопште, унапређења околине и очувања природе.