Zavod za zaštitu prirode Crne Gore *Ministarstvo održivog razvoja i turizma*

NAUČNI SKUP SA MEĐUNARODNIM UČEŠĆEM ▌INTERNATIONAL CONFERENCE

ZAŠTITA PRIRODE U XXI VIJEKU

NATURE PROTECTION IN XXIST CENTURY

ZBORNIK REFERATA, REZIMEA REFERATA I POSTER PREZENTACIJA (KNJIGA BR 2)

Radovi su objavljeni u obliku dobijenom od autora

▌▌

PROCEEDINGS OF THE CONFERENCE (BOOK No 2)

Articles published in the Proceedings are given with the content received from the authors

20 – 23 Septembar 2011.
Žabljak, Crna Gora / Montenegro

ORGANIZACIONI ODBOR

PREDSJEDNIK
Dr Zlatko Bulić, direktor Zavoda za zaštitu prirode Crne Gore

ČLANOVI:
Mr Ivana Vojinović, pomoćnik Ministra održivog razvoja i turizma
Dr Aleksandar Joksimović, direktor Instituta za biologiju mora
Mr Luka Mitrović, direktor Hidrometeorološkog zavoda Crne Gore
Daliborka Pejović, direktorica Agencije za zaštitu životne sredine
Rade Gregović, direktor JP „Nacionalni parkovi Crne Gore"
Branko Žugić, direktor Geološkog zavoda Crne Gore
Rajko Barović, direktor JP "Morsko dobro"
Nada Medenica, direktor JU"CETI",Podgorica
Prof. dr Vladimir Pešić, Šef odsjeka za biologiju – PMF, Podgorica
Ondrej Vizi, direktor Prirodnjačkog muzeja Crne Gore
Zoran Janković, direktor Uprave za vode
Tomo Pajović, direktor NP „Durmitor"
Mr Darko Brajušković, direktor NP „Biogradska gora"
Mr Zoran Mrdak, direktor NP „Skadarsko jezero"
Baćko Uskoković, direktor NP „Lovćen"
Dr Dragan Roganović, Zavod za zaštitu prirode Crne Gore
Mr Vasilije Bušković, Zavod za zaštitu prirode Crne Gore
Dr Vesna Mačić, Institut za biologiju mora Kotor
Dr Ruža Ćirović, Zavod za zaštitu prirode Crne Gore
Mr Sead Hadžiablahović, Zavod za zaštitu prirode Crne Gore
Dr Goran Barović, Filozofski fakultet Nikšić – Odsjek za Geografiju
Dr Gojko Nikolić, Filozofski fakultet Nikšić – Odsjek za Geografiju
Mr Gordana Kasom, Zavod za zaštitu prirode Crne Gore
Milenko Damjanović, direktor Centra za savremenu umjetnost Crne Gore
Miroje Džabasan, direktor Centra za kulturu, Žabljak

POČASNI ODBOR

ČLANOVI:
Prof. dr Predrag Miranović, rektor UCG
AkademikPerko Vukotić,, CANU
Akademik Božidar Nikolić, DANU
Akademik Milorad Mijušković, CANU
Akademik Branko Radojičić, DANU
Akademik Ljubomir Berberović, ANUBiH, Sarajevo i CANU Podgorica
Akademik Midhat Ušćuplić, ANUBIH
Slavoljub Stijepović, Ministar prosvjete i sporta
Dr Sonja Vlahović, Ministar nauke
Tarzan Milošević, Ministar poljoprivrede i ruralnog razvoja,
Branislav Mićunović, Ministar kulture i medija,
Branimir Gvozdenović, Podgorica,
Predrag Nenezić, Podgorica
Dr Miodrag Gomilanović, Podgorica
Predrag Jelušić, direktor HTP „Primorje" Tivat
Prof. dr Blagoje Cerović, dekan, Filozofski fakultet, Nikšić
Prof. dr Radovan Bakić, Filozofski fakultet, Nikšić
Dr Dušan Dragović, naučni savjetnik, Podgorica
Dr Vasilije Radulović, naučni savjetnik
Prof. dr Mihailo Burić, Filozofski fakultet Nikšić
Prof. dr Slobodan Kasalica, Filozofski fakultet, Nikšić
Ana Mišurović, JU „CETI", Podgorica
Dr Đorđije Drecun, Podgorica
Mr Salija Adrović, srednjo-školski centar Berane
Zoran Tomić, sekretar Ministarstva održivog razvoja i turizma
Daniel Vincek, Botanička bašta planinske flore Crne Gore, Kolašin
Isailo Šljivančanin, predsjednik opštine Žabljak

NAUČNI ODBOR

PREDSJEDNIK
Akademik Vukić Pulević

ČLANOVI:
Akademik Gordan Karaman – CANU. Podgorica
Akademik Vladimir Stevanović, SANU - Beograd
Akademik Sulejman Redžić, ANUBiH - Sarajevo
Akademik Vlado Matevski, PMF - Skoplje
Prof. dr Sreten Mandić, Institut za biologiju mora Kotor
Prof. dr Miljan Radović, Beograd
Prof. dr Milutin Lješević, Filozofski fakultet, Nikšić
Prof. dr Ivica Radović, Beograd
Dr Deni Porej, WWF
Dr Boris Erg, IUCN
Davorin Marković, Državni zavod za zaštitu prirode Hrvatske, Zagreb
Prof. dr Jasenka Topić, PMF, Zagreb
Prof. dr Nenad Stavretović, Zavod za zaštitu prirode Srbije
Prof. dr Ljupče Melovski, PMF - Skoplje
Dr Darij Krajičić, Zavod za zaštitu prirode Slovenije
Dr Boštjan Surina, Prirodoslovni muzej, Rijeka
Dr Biljana Panjković, Zavod za zaštitu prirode Vojvodine
Prof. dr Branislav Glavatović, Seizmološki zavod Crne Gore
Prof. dr Predrag Stanišić, PMF, Univerzitet Crne Gore
Prof. dr Rifat Škrijelj, PMF-Odsjek za biologiju Sarajevo
Dr Zlatko Bulić, Zavod za zaštitu prirode Crne Gore
Prof. dr Mićko Radulović, Građevinski fakultet Univ. Crne Gore
Prof. dr Milorad Gojković, Institut za biologiju mora Kotor
Prof. dr Zoran Kljajić, Institut za biologiju mora, Kotor
Prof. dr Nenad Vuksanović, Institut za biologiju mora, Kotor
Prof. dr Staniša Ivanović, Filozofski fakultet, Nikšić
Prof. dr Miroslav Doderović, Filozofski fakultet, Nikšić
Mr Dragutin Nedić, Podgorica
Mr Halil Markišić, Rožaje
Prof. dr Milivoje Purić, PMF – Odjek za biologiju UCG
Prof. dr Drago Marić, PMF – Odjek za biologiju UCG
Prof. dr Dmitar Lakušić, PMF – Odsjek za biologiju, Beograd
Prof.dr Vladimir Ranđelović, PMF, Niš
Prof. dr Marash Rakaj, PMF Skadar, Albanija
Dr Slobodan Vukčević, Podgoria
Prof. dr Natalija Perović, Biotehnički fakultet, Podgorica

SEKRETARIJAT

ČLANOVI:
Mr Nataša Stanišić, Zavod za zaštitu prirode Crne Gore
Mr Milka Rajković, Zavod za zaštitu prirode Crne Gore
Vesna Jovović, Zavod za zaštitu prirode Crne Gore
Mr Rajko Tripić, Zavod za zaštitu prirode Crne Gore
Mr Sonja Kralj, Zavod za zaštitu prirode Crne Gore
Jelena Nikčević, Zavod za zaštitu prirode Crne Gore
Darko Saveljić, Zavod za zaštitu prirode Crne Gore
Mr Biljana Telebak, Zavod za zaštitu prirode Crne Gore
Nataša Miličković, Zavod za zaštitu prirode Crne Gore
Milica Jovanović, Zavod za zaštitu prirode Crne Gore
Mitar Baranin, direktor hotela „Planinka", Žabljak

GENERALNI SEKRETAR:
Mr Vasilije Bušković

ADAPTIVE GROWTH OF *PICEA OMORIKA* ROOTS IN RESPONSE TO STATIC BENDING STRESS

ALEKSANDRA MITROVIĆ[1], JASNA SIMONOVIĆ[1], KSENIJA RADOTIĆ[1], DRAGOSAV MUTAVDŽIĆ[1], JELENA BOGDANOVIĆ-PRISTOV[1]

Abstract

Picea omorika (Pančić) Purkyně is a Balkan endemic coniferous species and Tertiary relict of the European flora. Its natural habitat is reduced to the mountain Tara and the Drina river valley. They inhabit open habitats, such as cliffs, forest clearings and vegetation gaps. Besides extreme variations in temperature, light intensity and water availability, *P. omorika* habitats on mountain Tara are characterized by strong northern wind. A tree growth response to movement includes changes in branch and foliar development, stem and base of structural roots. In coniferous species stem and structural roots thickening occurs on compression side of bending.

To simulate the effect of strong northern wind, snow or rockfall (that all characterize *P. omorika* natural habitats) on root development, we applied static bending stress on 3 years old *P. omorika* plants. Stimulation of fine roots growth occurred on the tension side of bending. Dry weight of fine roots was 7.5 or 5.2 times bigger in plants subjected to static bending stress compared to control plants, as early as after 2 or 4 weeks, respectively.

The form of adaptive fine roots growth in response to static bending force improve rapid anchorage of the plant on the tension side of bending and increase the mass of the soil-root plate, whereby increases the young tree resistance to overturning. It could be a part of *Picea omorika* adaptive strategy to survive in their natural habitats.

Key words: fine roots, *Picea omorika* (Pančić) Purkyně, static bending, wind.

Introduction

Plant development is highly responsive to environmental stimuli. Such plasticity is one way in which plants overcome their inability to move toward areas or away from regions of adverse conditions.

Picea omorika (Pančić) Purkyně is an endemic conifer tree. It is a Balkan endemic species and Tertiary relict of the European flora. Nowadays its natural habitat is reduced to the middle and upper courses of the Drina river. They inhabit open habitats, such as cliffs, forest clearings and vegetation gaps. Besides extreme variations in temperature, light intensity and water availability, P. omorika habitats on mountain Tara are characterized by northern wind of constant intensity of about 221 ‰ during vegetation period (Bogdanović et al., 2007).

Resistance of forest trees to breakage or overturning in windy climates depends largely on structural modifications for mechanical strength. Trees continuously alter their morphology in response to changes in wind exposure. When subjected to a force due to the wind, or to force applied artificially, they bend. Trees growth responses to movement include changes in development of leafs, branches, stem and base of structural roots (jaffe, 1973; barlow, 1994; blackwell et al., 1990). Leaning stem develops abnormal wood (reaction wood) which serves either to reorient the stem, or to prevent further lean. In gymnosperms reaction wood formation occurs on the lower side of the lean (compression wood) whereas in arboreal dicotyledons this occurs on the upper side (tension wood) so as to produce eccentric stems (bamber, 2001). Radial growth of structural roots as the result of bending stress, similarly to stem thickening, differs in coniferous and angiosperm species. In gymnospermes grater root thickening is on the leeward side relative to prevailing wind direction, implying that they function in compression (nicoll and ray, 1996). In angiosperms root thickening is larger on the windward side of the tree and appears to function for strength in tension (barlow 1994).

There are a large number of studies focused on responses of coniferous species to wind loading. Much of them study the influence of mechanical stress on the above-ground parts of the tree. Less

[1] Institute for Multidisciplinary Research, University of Belgrade, Kneza Višeslava 1, Belgrade, Serbia; mita@imsi.rs

data is focused on responses in root system of mechanically perturbed plants, mainly providing information on structural roots of aged trees after a long term wind exposure.
Our result describes changes in root development of young 3 years old *P. omorika* plants as early as after 2 weeks of exposure to static bending stress.

Material and methods

Three years old *P. omorika* plants were grown in plastic pots (20 x 20 x 20 cm) in the garden of the Institute for Biological research "Siniša Stanković" in Belgrade. Plants were about 70 cm high. Static bending stress was carried out at the end of the growing season, in September 2009.
Bending was performed at 37 cm from the base of the stem by wiring (bending angle was about 90 degrees). The same bending force among 8 replicate plants was provided by using wire of the same length and fixing it to the edge of each pot (Figure 1).
As a control we used 8 plants of the same age, grown under the same conditions as treated plants before static bending was applied.

Figure 1. Static bending by wiring was performed at 37 cm from the base of the stem in 3 years old *Picea omorika*. Wires of the same length were fixed to the edge of the pot.
Slika 1. Statičko savijanje ožičavanjem primenjeno je na 37 cm od osnove stabla 3 godine starih biljaka *Picea omorika*. Žice jednakih dužina fiksirane su za ivice saksija.

Two and 4 weeks after static bending stress were applied, the 4 plants were taken out of the pots and the remainder of the soil from the root system was gently washed. Fine roots (Figure 2) were excised from both, plans subjected to static bending stress and control plants, dried for 24h at 75 °C and weighed.

Results and discussion

As a consequence of the numerous storms in the last few decades, researchers are dedicating more resources to the problems of tree stability and to fundamental role of the root system in ensuring anchorage.
Plant root system development is a complex process involving several internal and environmental factors and their mutual interactions. Tree root system can be divided into structural and fine roots.

The structural (woody) roots serve anchorage, transport and storage functions. Fine roots (often defined as ≤ 2 mm in diameter) are generally recognized as a very important component of the root system, representing a substantial link between the tree organism and the soil (KOZLOWSKY and PALLARDY, 1997). The acquisition of essential resources from the highly heterogeneous soil volumes is performed by small absorbing roots (fine roots) and their mycorrhizal associates (PREGITZER, 2002). "We may eventually learn that variability in fine root branch structure and function is just as anatomically, physiologically and ecologically important as is variability in shoot system structure and function" (PREGITZER, 2002).

COUTTS (1986) separated resistance of trees to uprooting in windy climates into 4 components: 1 - resistance to bending of the leeward side roots; 2 - anchorage of windward roots under tension; 3 - mass of the soil-root plate; and 4 - resistance of soil to breaking.

In coniferous species structural modifications of roots for resistance to bending include allocation of more biomass of structural roots on the compression side of bending and changes in their shape. For example, shallow rooted *Picea sitchensis* trees allocate more biomass to structural roots on the compression side relative to prevailing wind direction which reduce bending in the soil-root plate and increases resistance to overturning (QUINE et al, 1991, NICOL et al., 1996). Resistance to bending also occurs through changes in the shape of structural roots on the compression side of bending in several conifer species (NICOLL and RAY, 1996) associated with shallow rooting and with the type of the soil. Different conifer species, growing in sphagnum moss above shallow water table or on waterlogged peat, form major roots in the shape of I-beam, T-beam or oval. This shape uses minimum material to maximize resistance to bending and to increase the rigidity of the soil root plate (RIGG and HARRAR, 1931, WOOD 1995; NICOLL and RAY, 1996).

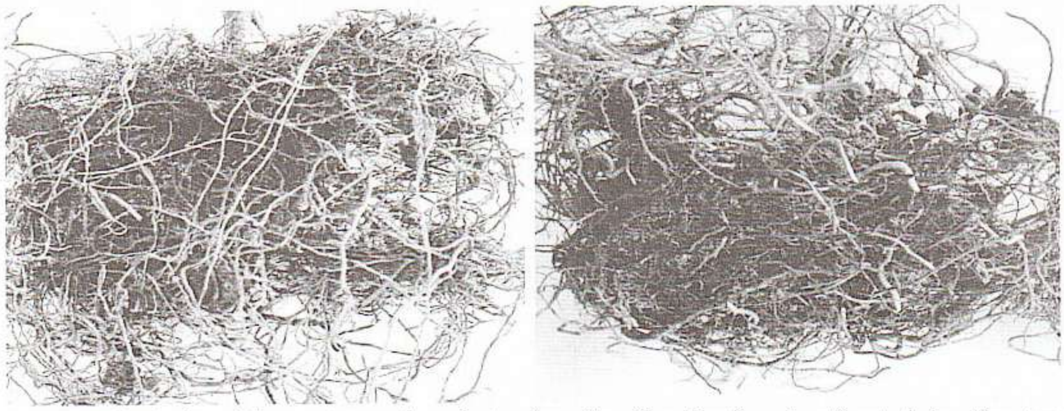

Figure 2. Stimulation of fine roots growth on the tension side of bending 2 weeks after static bending stress was applied on 3 years old *P. omorika* plants; left – root of control plants, right – root of bent plants.
Slika 2. Stimulacija rastenja mladih korenov na tenzionoj strani savijanja 2 nedelje nakon primene stresa savijanjem na 3 godine stare biljke *Picea omorika*; levo – koren kontrolne biljke, desno – koren savijene biljke.

To elucidate the effect of wind, snow or rockfall on root development of young *P. omorika* trees on its natural habitats, we applied static bending stress on 3 years old *P. omorika* plants (Figure 1). Significant stimulation of fine roots growth occurred on the tension side of bending (Figure 2). Dry weight of fine roots was 7.5 or 5.2 times higher in plants subjected to static bending stress compared to control plants, as early as after 2 or 4 weeks, respectively (Table 1).

Table 1. Stimulation of fine roots growth 2 and 4 weeks after static bending by wiring was applied on 3 years old *Picea omorika* plants;dw – dry weight; n = 4.
Tabela 1. Stimulacija rastenja mladih korenova 2 i 4 nedelje posle primene statičnog savijanja ožičavanjem na 3 godine stare biljke dw – suva masa; n = 4.

Time after static bending was performed	Control plants Fine roots dw (g)	Bent plants Fine roots dw (g)
2 weeks	0.02 ± 0.01	0.15 ± 0.03

4 weeks	0.04 ± 0.01	0.21 ± 0.09

Stimulation of fine roots growth that occurred as early as 2 weeks after static bending stress was applied to 3 years old *P. omorika* plants (Table 1) could be linked with 3rd and 4th component of COUTTS (1986) resistance to uprooting. The increase in mass (number) of fine roots on the tension side of bending only 2 weeks after static bending was applied could both – rapidly improve anchorage of the root on the tension side of bending and increase the mass of the soil-root plate, thereby increasing the tree resistance to overturning. This early and rapid response of 3 years old *P. omorika* plants to static bending stress could be a part of adaptive strategy of young *Picea omorika* trees to survive in their natural habitats: cliffs and forest clearings often exposed to strong northern wind, snow or rockfall.

Conclusions

Contrary to the long term exposure of aged coniferous trees to mechanical force that cause changes in mass and shape of structural roots on the compression side of bending, we suggest that in young *Picea omorika* plants early response to bending stress includes rapid stimulation of fine roots growth on the tension side of bending. Such strategy could rapidly improve anchorage of the root on the tension side of bending and increase the mass of the soil-root plate, thereby increasing the young tree resistance to overturning, i.e. enabling *Picea omorika* young plants to survive in their natural habitats.

Acknowledgment: This work was supported by a grant (No. 173017) from the Ministry of Education and Science of the Republic of Serbia.

References

1. BAMBER, R.K., 2001: A general theory for the origin of growth stresses in reaction wood: how trees stay upright. *IAWA Journal* 22: 205-212.
2. BARLOW, P.W., 1994: The origin, diversity and biology of shoot-borne roots. In: *Biology of adventious root formation*. Eds. T.D. Davies and B.E. Hassing. Plenum Press, New York, pp 1-23.
3. BLACKWELL, P.G., RENNOLLS, K., COUTTS, M.P., 1990: A root anchorage model for shallowly rooted Sitka spruce. *Forestry* 63: 73-91.
4. BOGDANOVIĆ, J., MILOSAVIĆ, N., PRODANOVIĆ, R., DUČIĆ, T., RADOTIĆ, K., 2007: Variability of antioxidant enzyme activity and isoenzyme profile in needles of Serbian spruce (*Picea omorika* (Panč.) Purkinye). *Biochemical Systematics and Ecology* 35: 263-273.
5. COUTTS, M.P., 1986: Components of tree stability in Sitka spruce on peaty gluey soil. *Forestry* 59: 173-197.
6. JAFFE, M.J., 1973: Thigmomorphogenesis: the response of plant growth and development to mechanical stimulation. *Planta* 114: 143-157.
7. KOZLOWSKY, T.T., PALLARDY, S.G., 1997: *Physiology of woody plants*. San Diego, Academic Press: 411.
8. NICOLL, B.C., RAY, D., 1996: Adaptive growth of tree root system in response to wind action and site conditions. *Tree Physiol.* 16: 891-898.
9. PREGITZER, K.S., 2002: Fine roots of trees – a new perspective. *New Phytologist* 154: 267–270
10. QUINE, C.P., BURNARD, A.C., COUTTS, M.P., REYNARD, B.R., 1991: Effects of mounds and stumps on the rot architecture of Sitka sprooce on a peaty gley restocking site. *Forestry* 64: 385-401.
11. TAMASI, E., STOKES,A., LASSERRE, B., DANJON, F., BERTHIER, S., FOURCAUD, T., CHIATENTE, D., 2005: Influence of wind loading on root system development and architecture in oak (Quercus robur L.) seedlings. *Trees* 19: 374-384.
12. RIGG, G.B., HARRAR, E.S., 1931: The root systems of trees growing in sphagnum. *American Journal of Botany* 18: 391-397.
13. WOOD, C.J., 1995: Understanding wind forces on trees. In: *Wind and Trees*. Eds. M.P. Coutts and J. Grace. Cambridge University Press, Cambridge, pp 133-164.