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Original Article

Total content of organic acids in plants from fire affected forest

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***Abstract*:**
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In 2007 catastrophic fire on Vidlič Mountain had been occurred. It had been burned down nearly 1000 hectares of forest. That year vegetation was totally destroyed. Ecosystems affected by fire are those with great changes in variety of ecological parameters and they can recover by natural succession. Post fire areas are being occupied by pioneer plants which start one natural cycle. Total organic acids content in plants from fire affected forest was studied and the same plant species from forest which had not been affected by fire were taken as a control. Total organic acids content for all plants from forest affected by fire was higher than for plants from fire non affected forest except one plant (*Aegopodium podagraria*).

Key words: organic acids, forest affected by fire, pioneer plants, Vidlič Mountain

Introduction

Fire is one of the basic natural forces that influence plant communities over evolutionary period of time. Certain plant communities require periodic fires to maintain their position in the ecosystem (M u t c h 1970). According to hypothesis of M u t c h (1970) fire-dependent plant communities burn more readily than fire-non-dependent communities, because natural selection has favored development of characteristics that make them more flammable. But, not every forest fire is consequence of natural disturbance. Some of them are appeared after human activity and have more sever consequences on landscape and ecosystems. One of such had been appeared on Vidlič Mountain near Pirot town in June 2007 and had last for 10 days and almost 1000 hectares of forest were burnt down. After expiration of fire only grate amount of dust was remained.

Forest fires create the conditions which are favorable for certain plant species that were not present in that ecosystem earlier or which were presented but with very few number, and they are known as pioneer plants. These plants are specific because they face with many unfavorable ecological factors such as: high illumination, high temperature, low moisture, increased evaporation and finally significant changes in soil composition.

Fire affected landscapes are very specific according their ecological factors and soil compositions. So, it is very interesting to examine

biochemical and physiological parameters in plants which inhabit that kind of landscapes. The total amount of organic acids in pioneer plants from fire affected forest has been investigated, taking into consideration their importance as indicators of physiological status of plants and effects of ecological factors on them.

Material and methods

The plant material had been collected one year after forest fire. Four plant species have been chosen. Control group of plants was collected in the same time but from forest which hadn't been affected by fire. Tested plants were: *Fagus moesiaca* (K.Malỳ) Czeczott, *Tussilago farfara* L., *Doronicum columnae* Ten. and *Aegopodium podagraria* L..

The method by Pleshkov (1985) was applied for determination of total organic acids content. Accurately weighted mass (20.00 g) of fresh plant material was extracted in blender with 150 ml of distillated water, transferred into Erlenmeyer flask and heated in water bath at 70ºC for 30 minutes. After that extract was filtered and total volume of filtrate was adjusted to 200 ml. The filtrate aliquot of 50 ml was transferred into Erlenmeyer flask and titrated with 0.1 mol/l standard solution of NaOH. The titration endpoint was registered potentiometrically. Acidity was calculated by formula:

X=axTx200x10/nx50

where:

X=content of acids in analyzed solution in mekv/g of fresh plant material,

a = volume of 0.1 mol/l standard solution of NaOH used for titration in ml,

T = factor of 0.1 mol/l standard solution of NaOH,

200 = total filtrate volume in ml,

10 = factor for calculating mekv of acids

n = mass of plant material used for extract preparation,

50 = volume of filtrate aliquote

Results and discussion

Organic acids are secondary metabolites, produced by degradation of carbohydrates, fats and proteins and mostly include: oxalic, formic, citric, fumaric, malic, succinic, acetic and phosphoric acids as well as many others which arise in lower amount (Rivasseau et al., 2006). Accumulation of some specific organic acids in plants is in relationship with their enzymatic reactions, growing and development. Also, their abundance is under effect of different ecological factors.

Biochemical function of organic acids is dependent on different ecological conditions. They are donors of protons in some oxido-reduction reactions, for example -conversion of malic to oxalic acid. Some earlier studies showed that content of organic acids in plants is dependent on respiration, transpiration, various biochemical processes in plants, plant's phenophase (Gašić, 1992).

Fig. 1. *Doronicum columnae* Ten.

Fig. 2. *Aegopodium podagraria* L.

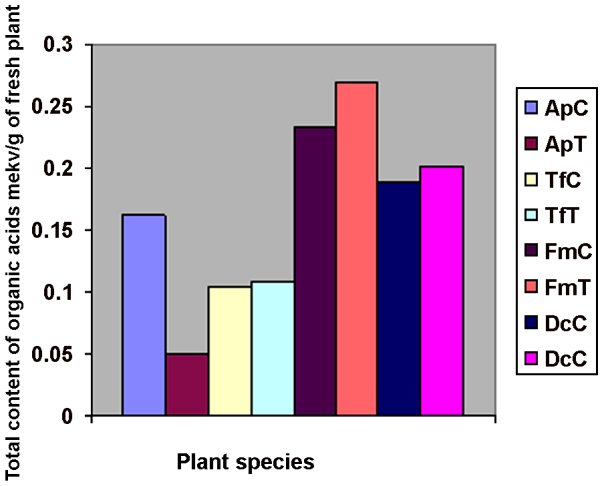

Fig. 3. Total content of organic acids in some plant species (Ap C= *Aegopodium podagraria* control; Ap T= *Aegopodium podagraria* test plant; Tf C= *Tussilago farfara* control; Tf T= *Tussilago farfara* test plant; Fm C= *Fagus moesiaca* control; Fm T= *Fagus moesiaca* test plant; Dc C= *Doronicum columnae* control; Dc T= *Doronicum columnae* test plant)

Obtained results indicate that the content of organic acids in plants are different in analyzed plant species but, in general, they are higher for plants from fire affected areas than in control plants. The only exception is *Aegopodium podagraria* which has lower total content of organic acids compared with control plant and it is 0.05 mekv/g of fresh weigh in test plant and 0.162 mekv/g of fresh weigh (**Tab. 1**).

The highest total content of organic acids in tested plants compared with control had been found in *F. moesiaca* and it is 115.38% in comparison to the control. The content total content of organic acids in plants from post fire area was 0.270 mekv/g, while in control plants that amount was 0.234 mekv/g (**Tab. 1**) Common beech is perennial plant and seedlings which were examined were one year old shoots. Acorns had been produced in the same year when forest fire had occurred or one year before that. They had been exposed to heat, fire, fume, dust, high illumination and low humidity which are unfavorable conditions for germination and development of seedlings and so they can be considered as stressed. In those situations plants activate defense mechanisms which are numerous. Some of them are species specific, while the others are common for huge number of species (Trajković et al., 2007). Plant's organic acids have very important role in plant detoxification caused by heavy metals (Jones, 1998; Ma, 2000; Ma et al., 2001).

The lowest level of total organic acids had been found in *A. podagraria*, and it was supposed that it has different defense mechanisms as well as specific morphological characteristics that are very important for adaptations and survivor in stress conditions (Trajković, 1995; Trajković et al., 2007).

In *D. columnae* the total content of organic acids was 0.202 mekv/g in tested plants and 0.189 mekv/g in control plants. In *T. farfara* the content in tested plants is 0.108 mekv/g and 0.103 mekv/g in control plants.

It had been established that content of organic acids can vary in underground and up ground plant organs in the same species (Trajković, 1995; Trajković et al., 2007). They are of different anatomy, morphology and defenses mechanisms which are genetically caused. It was supposed that plant organs have different activities, different needs and different active processes.

Analysis of soil indicates that soil which was affected by fire was mineralized and enriched with mineral elements (**Tab. 2**) and some of them are not favorable for plant grow and development (Jones, 1998).

Organic acids are needed for detoxification from heavy metals. They make helate complexes with them and enable their circulation in plant. In the same time that complexes are accumulated in plant organs which later can be excreted (Jones, 1998; Ma, 2003; Arnetoli et al., 2008.).

On the other hand it had been demonstrated that iron deficiency causes a substantial accumulation of organic acids in root tissues and also includes a large increase in H^+ and organic acids excretion (De Vos et al., 1986; Guerinot & Yi, 1994; Ohwaki & Sugahara, 1997). Except that, deficiency of phosphorus (Hoffland et al., 1989; Johnson et al., 1996; Dakora & Phillips, 2002) or elevated concentrations of Al^{3+} ions lead to increasing exudation of organic acid anion in some species (Li et al., 2002; Pirenos et al., 2002).

It is reported that higher content of organic acids have plants which are tolerant to particular metal (Delhaize et al., 1993; Basu et al., 1994).

Conclusion

According all this facts and results which were presented one conclusion is irrevocably: synthesis of organic acids is one of the major defense mechanism in plant reaction on stress conditions. It is known that high concentrations of heavy metals cause increase content of organic acids

Table 1. Comparison of total content of organic acids in some plants from post fire region from Vidlic Mountain with control plant group (mekv/g fresh weigh)

Plant species	control	test plant	% compared with control
Aegopodium podagraria L.	0.162	0.050	30.86
Tussilago farfara L.	0.103	0.108	104.85
Doronicum columnae Ten.	0.189	0.202	106.88
Fagus moesiaca (K. Malý) Czeczott	0.234	0.270	115.38

Table 2. Total content of heavy metals in soil from fire affected and fire non affected forest areas

Metal (ppm) plant species		Pb	Cd	Cu	Zn	Fe
from fire affected soil	*A. podagraria*	113.12	0.21	15.78	50.93	9893.64
	F. moesiaca	1.94	0	3.92	0	7367.97
	T. farfara	202.79	3.545	35.25	130.14	12840.17
	D. columnae	146.23	1.89	25.91	56.22	5236.11
from non fire affected soil	*A. podagraria*	30.92	0	13.60	18.10	10764.98
	F. moesiaca	14.18	0	18.94	0	16813.46
	T. farfara	10.14	2.29	12.32	0	10687.54
	D. columnae	34.33	3.50	16.07	37.01	14401.91

in plants (Vergana & Gabrielli, 1987; Trajković, 1995; Trajković et al., 2007). Plants on fire affected forest region are high adaptive plants and have mechanism for survival. They can change environment and make favorable conditions for natural succession and invasion of the other plant species.

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