ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2005, Tome III, Fascicole 3

THE EFFECT OF NICKEL ON PHOTOSYNTHETIC PARAMETERS AND BIOMASS PRODUCTION IN POPLAR CLONES

NIKOLIĆ, N.[1], PILIPOVIĆ, A.[2],
KRSTIĆ, B.[1], ORLOVIĆ, S.[2]

[1]FACULTY OF NATURAL SCIENCES,
DEPARTMENT OF BIOLOGY AND ECOLOGY,
NOVI SAD, SERBIA & MONTENEGRO.
[2]FACULTY OF AGRICULTURE,
INSTITUTE OF LOWLAND FORESTRY AND ENVIRONMENT,
NOVI SAD, SERBIA & MONTENEGRO

1. INTRODUCTION

Contamination of the environment with toxic heavy metals is a mayor environmental problem. Nickel is one of the essential micronutrients for plants, but toxic at elevated concentrations. General symptoms of heavy metal toxicity for plants are chlorosis and decreased growth [3]. Elevated concentrations of Ni can inhibit cell division at root meristems in non-tolerant plants [5].

Also, previous studies showed that Ni has a negative effect on photosynthesis and respiration [1]. Hybrid poplars were originally bred and grown as a cash crop for such uses as pulpwood and as renewable energy source. Because of their rapid growth and high evapotranspiration rates, they make ideal candidates for phytoremediation.

According to Chappel [2], advantages of genus *Populus* in phytoremediation are: great number of species, fast growth up (3-5m/year), high transpiration rate (100 liters/day) and not part of food chain. Detoxification of soils and waters containing toxic heavy metals using poplars has been demonstrated for various species.

Also, it was shown that varieties within the same species exhibit different responses to heavy metal presence. Hence, the aim of this study was to investigate responses of growth and photosynthetic parameters in different poplar clones to Ni in the growing medium.

These results could give the guidelines in selection of clones from our Institute's collection, potentially useful in phytoremediation of Ni contaminated sites.

2. MATERIALS AND METHODS

Woody cuttings of three poplar clones (9111/93, M-1, and B-81) were rooted in pure water. After that period, plants were grown hydroponically in Hoagland's nutrient solution [4] supplemented with 0 (control), 10^{-6}, 10^{-5}, and 10^{-4} M Ni ($NiSO_4$). After two-month exposure, biomass production and photosynthetic parameters were studied.

The root, stem, and leaf biomass were expressed as fresh mass (g). Leaf area was assessed using photoelectric leaf are meter (LI-COR 3000) and expressed as leaf area per leaf (cm^2). The photosynthetic activity and dark respiration rate were determined polarographically [6].

The concentration of chloroplast pigments – total chlorophyll (Chl *a+b*), and total carotenoids was determined spectrophotometrically and expressed as mg g^{-1} DM [7]. The data were calculated using the LSD and Duncan's test. Means with the same letter did not differ significantly at $p<0.05$ level.

3. RESULTS AND DISCUSSION

The effects of Ni on growth parameters are given in Table 1. The greatest number of leaves was found in 9111/93 clone, while B-81 clone developed leaves with the biggest leaf area (79.46 cm^2, on average).

TABLE 1. THE RESPONSE OF LEAF NUMBER, LEAF AREA (cm^2), AND BIOMASS PRODUCTION (g) IN POPLAR CLONES TO VARIOUS CONCENTRATIONS OF NI IN NUTRIENT SOLUTION

CLONE	TREATMENT M Ni	NUMBER OF LEAVES per plant	LEAF AREA	FRESH MASS		
				leaf	stem	root
9111/93	0 (control)	32.2 a	50.66 bc	0.79 bcd	13.90 ab	14.12 b
	10^{-6}	30.6 ab	55.96 b	0.92 b	15.17 a	11.20 cd
	10^{-5}	25.0 cd	55.37 b	0.77 bcd	10.41 cd	10.05 def
	10^{-4}	26.8 bc	39.56 c	0.58 d	8.14 d	4.66 g
M-1	0 (control)	22.0 d	53.12 b	0.82 bc	8.77 d	11.01 de
	10^{-6}	22.4 cd	52.70 b	0.82 bc	8.93 cd	10.58 def
	10^{-5}	22.4 cd	52.98 b	0.62 cd	9.58 cd	8.78 ef
	10^{-4}	21.2 d	56.01 b	0.87 b	11.78 bc	8.53 f
B-81	0 (control)	26.8 bc	74.57 a	1.17 a	10.88 cd	18.70 a
	10^{-6}	22.4 cd	78.14 a	1.15 a	10.63 cd	15.12 b
	10^{-5}	23.2 cd	82.60 a	1.28 a	9.77 cd	13.34 bc
	10^{-4}	15.8 e	82.52 a	1.30 a	8.25 d	14.06 b

Leaf area and number per plant were not affected in M-1 clone. Results showed differences in shoot and root biomass between treatments, but variability between clones was evident. The production of aboveground biomass was altered by Ni in 9111/93 and M-1 clones.

With the exception of B-81 clone, there were no significant differences in dark respiration between treatments (Table 2). The highest photosynthetic and dark respiration rates were recorded in B-81 clone (2132, i.e. 3840 nmol O_2 $cm^{-2}h^{-1}$, respectively).

Compared with control plants, photosynthetic oxygen evolution was lowered, and dark respiration rate was unaffected in 9111/93 and M-1 clones in the presence of Ni. There were some significant differences in Chl *a+b* and carotenoid concentrations between treatments (Table 2).

In contrast to M-1 clone, chlorophyll and carotenoids synthesis was lowered in 9111/93 clone.

TABLE 2. THE RESPONSE OF CHLOROPLAST PIGMENT CONCENTRATIONS (mg g^{-1} DM), PHOTOSYNTHETIC (nmol O_2 cm^{-2} h^{-1}) AND DARK RESPIRATION RATES (- nmol O_2 cm^{-2} h^{-1}) IN POPLAR CLONES TO VARIOUS CONCENTRATIONS OF Ni IN NUTRIENT SOLUTION

CLONE	TREATMENT M Ni	Chl a+b	Chl a/ Chl b	CAROTENOIDS	THE RATE OF	
					photosynthesis	dark respiration
9111/93	0 (control)	12.10 a	3.12	2.49 ab	1910 b	2393 d
	10^{-6}	11.44ab	2.91	2.51 ab	1289 de	2026 d
	10^{-5}	7.31 de	2.61	1.60 ef	1811 bc	2240 d
	10^{-4}	1.89 f	3.16	0.54 g	1243 de	1932 d
M-1	0 (control)	6.46 e	2.95	1.41 f	1619 bcd	2164 d
	10^{-6}	8.93 cd	2.83	2.05 bcde	1059 e	2348 d
	10^{-5}	9.15 cd	2.83	1.96 cde	1381 cde	2256 d
	10^{-4}	8.05 cde	3.00	1.91 de	1289 de	2164 d
B-81	0 (control)	12.95 a	2.99	2.67 a	2985 a	4577 a
	10^{-6}	9.87 bc	2.55	2.11 bcd	1827 bc	3959 ab
	10^{-5}	12.30 a	2.59	2.63 a	1888 b	3107 c
	10^{-4}	9.90 bc	2.85	2.40 abc	1827 bc	3716 bc

4. CONCLUSION

The results obtained suggest that M-1 clone was the least affected by heavy metal presence, so this clone could be grown at Ni contaminated sites.

5. ACKOWLEDGEMENT

This study was conducted within the Project TR-6864B, supported by The Ministry of Science, Technology and Development of the Republic of Serbia.

6. REFERENCES

[1.] CARLSON, R.W., BAZZAZET, F.A., ROLFE, G.L. 1975. The effect of heavy metals on plants. II. Net photosynthesis and transpiration of whole corn and sunflower plants treated with Pb, Cd, Ni and Tl. Environ. Res. 10, 113-120.

[2.] CHAPPELL J. (1997), Phytoremediation of TCE using Populus, Status Report prepared for the U.S. EPA Technology Innovation Office under a National Network of Environmental Management Studies Fellowship Compiled June - August 1997.

[3.] FOY, C.D., CHANEY, R.L., WHITE, M.C. 1978. The physiology of metal toxicity in plants. Ann. Rev. Plant Physiol. 29, 511-566.

[4.] HOAGLAND D.R., ARNON D.I. (1950), The water culture, method for growing plants without soil. Calif. Agric. Exp. Stn. Circ.347, 1-32.
[5.] ROBERTSON, A.I. 1985. The poisoning of roots of Zea mays by nickel ions, and the protection afforded by magnesium and calcium. New Phytol. 100, 173-189.
[6.] WALKER D.A. 1987. The use of the oxygen electrode and fluorescence probes in simple measurementsof photosynthesis, Oxygraphics limited, University of Sheffield print Unit, UK, 145.
[7.] WETTSTEIN D. 1957, Chlorophyll-letale und der Submikroskopische Formwechsel der Plastiden. Exp. Cell. Res. 12, 427-506.