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BRIEF COMMUNICATION

Clonal variability in photosynthetic and growth characteristics of *Populus deltoides* under saline irrigation

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Abstract

Fifty-d-old poplar (*Populus deltoides* L.) plants were irrigated with 50-200 mM NaCl. 100 and 200 mM NaCl significantly reduced net photosynthetic rate, chlorophyll and carotenoid contents, leaf area, dry matter accumulation, and harvest index (HI) in all tested poplar clones (Bahar, S7C15, and WSL22). Clone S7C15 was more tolerant to salinity than the other clones.

Additional key words: biomass; carotenoids; chlorophyll; CO_2 assimilation; harvest index; NaCl; poplar; root; shoot.

Soil salinity is one of major environmental stresses, which adversely affects plant/crop growth and yield, accompanied by decrease in photosynthetic characteristics (CO_2 assimilation, photosynthetic electron transport, photosynthetic pigments - Seemann and Critchley 1985, Long and Baker 1986, Therios *et al.* 1988, Dubey 1994, Hayashi and Murata 1998, Khavari-Nejad and Khaparzadeh 1998). The salinity induces decrease in photosynthetic capacity, because energy absorbed by light-harvesting chlorophyll (Chl) protein complexes (LHCPs) may not be utilized adequately by the photosynthetic carbon reduction process. Growth rate is generally reduced by salinity even at low salt concentrations in non-halophytes (Brugnoli and Lauteri 1991). Salinity significantly decreases leaf area ratio, but increases specific leaf mass and density of the leaf (Taleisnik 1987). An important primary effect of mild salinization is a reduction in leaf area which can in turn directly contribute to

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reduced photon flux density interception and thus to reduced plant photosynthetic potential and bioproductivity (Neumann *et al.* 1988, Papp *et al.* 1993). Salts accumulate in the upper layer of soil as a result of evapotranspiration under saline irrigation, which disturbs normal growth pattern of the seedlings.

Biomass production in poplar is related to its total leaf area (Isebrands and Nelson 1982, Singh 1996). Poplar is very adaptable, if grown under adverse climatic variables such as elevated temperature coupled with hot-dry atmospheric air and strong irradiance (Singh *et al.* 1996). This is connected with the intrinsic ability for altering fatty acid composition of thylakoid membrane which regulates membrane fluidity and better adaptation (Singh *et al.* 1993). Since information is not available on poplar seedling performance under salinity, we imposed various levels of salinity on poplar by irrigating with NaCl solutions (50-200 mM).

Cuttings from one-year-old plants of *Populus deltoides* L. were 15-18 cm long. They were kept vertically in tap water for one week to promote adequate root initiation, then transplanted into earthen pots (30×50 cm) containing fertile normal soil at the G.B. Pant University Campus, India. All pots were irrigated daily upto field capacity to maintain uniform growth. Fifty-d-old seedlings raised from the cuttings were irrigated with NaCl solutions (50-200 mM) prepared in normal tap water. Each time (after 20, 40, and 60 d) irrigation was maintained exactly upto the field capacity in both control and treatment pots. The Chl concentration in 7th leaf was determined in dimethyl sulphoxide (Hiscox and Israelstam 1979) extracts, while carotenoids (Cars) were extracted in diethyl ether (Arne 1978). The net photosynthetic rate (P_N) was monitored by infrared gas analyzer (IRGA, *CID-301 PS*, USA) at 10:00-11:00 h on physiologically mature leaves (Singh 1996, Singh *et al.* 1996) under field conditions [photosynthetically active radiation (PAR) 2100 μmol m^{-2} s^{-1}, relative humidity (RH) 55-60 %, temperature 31-33 °C]. After terminating the salinity experiment, the seedlings were separated into root, stem, and leaves to record their biomass parameters (Therios and Mesopolinas 1988). After recording fresh mass, these plant parts were oven dried at 70 °C for 3 d till constant mass. The harvest index (HI) was calculated (Michael *et al.* 1988) by dividing leaf+stem dry mass by total dry mass.

Increasing levels of salinity gradually reduced P_N in all poplar clones. This reduction was significantly affected by salt concentration rather than by salinity duration (Table 1). These findings are similar to those for glycophytes (Long and Baker 1986, Fedina *et al.* 1993). However, halophytes tolerate upto 400 mM NaCl without any decrease in P_N and photon yield of photosystem 2 (PS2) (Ball and Anderson 1986, Takabe *et al.* 1988). Thus the decline in P_N may be due to the loss of PS2 activity (Neumann *et al.* 1988) and disorganization of the light-harvesting Chl-protein complexes (LHCPs). The loss in P_N is further partially supported by unavailibility of CO_2 needed for carboxylation at the active site(s) of ribulose-1,5-bisphosphate carboxylase/oxygenase due to reduced stomatal conductance (Brugnoli and Lauteri 1991, Solomon *et al.* 1994, Allen *et al.* 1996).

The contents of Chl and Cars continuously declined parallel to the salinity concentration (Table 1). However, the Cars content was not changed under 50 mM NaCl. The decrease in Cars content may be slower than that of the Chls (Singh and

Table 1. Influence of salinity on chlorophyll (Chl) and carotenoid (Car) contents, net photosynthetic rate (P_N), and growth characteristics in poplar clones 60 d after salinity treatment. Results are the means ± SE for at least three to five independent experiments.

Parameter	Clone	NaCl [mM]			
		0	50	100	200
Chl *a* [g kg^{-1}(f.m.)]	S7C15	1.80±0.11	1.58±0.02	1.36±0.01	1.06±0.01
Chl *b* [g kg^{-1}(f.m.)]		0.71±0.04	0.67±0.03	0.58±0.01	0.47±0.03
Chl *a/b*		2.53±0.23	2.36±0.11	2.34±0.21	2.25±0.22
Car [g kg^{-1}(f.m.)]		0.26±0.02	0.26±0.04	0.22±0.01	0.16±0.02
Car/Chl		0.10±0.01	0.11±0.07	0.11±0.08	0.10±0.09
P_N [μmol m^{-2} s^{-1}]	Bahar	17.20±0.34	8.40±0.41	7.00±0.15	3.80±0.26
	S7C15	15.00±0.47	9.70±0.26	8.60±0.51	4.50±0.33
	WSL22	17.60±0.40	9.10±0.43	6.70±0.32	3.10±0.30
Leaf area [m^2]	Bahar	0.92±0.04	0.71±0.02	0.61±0.04	0.42±0.02
	S7C15	0.94±0.03	0.77±0.02	0.63±0.03	0.42±0.01
	WSL22	0.90±0.03	0.72±0.01	0.62±0.03	0.40±0.01
Shoot biomass [kg]	Bahar	0.42±0.02	0.35±0.02	0.28±0.04	0.17±0.01
	S7C15	0.41±0.01	0.36±0.01	0.31±0.02	0.22±0.02
	WSL22	0.42±0.03	0.30±0.02	0.26±0.01	0.14±0.03
Root biomass [kg]	Bahar	0.17±0.00	0.17±0.01	0.16±0.01	0.15±0.02
	S7C15	0.17±0.01	0.17±0.01	0.16±0.02	0.15±0.01
	WSL22	0.17±0.03	0.16±0.01	0.16±0.01	0.15±0.01
Harvest index [kg kg^{-1}]	Bahar	0.71±0.03	0.68±0.01	0.63±0.01	0.52±0.02
	S7C15	0.70±0.02	0.68±0.02	0.66±0.01	0.55±0.03
	WSL22	0.72±0.02	0.65±0.03	0.62±0.03	0.48±0.04

Dubey 1995). The Car/Chl ratio was not changed, the changes in Chl *a/b* were continuous, but also not significant.

The salinization resulted in reduced total leaf area in all clones (Table 1), similarly as reported by Neumann *et al.* (1988). The total leaf area was reduced by 20-50 % under our experimental conditions (50-200 mM) similarly as in cotton grown under 50 and 250 mM salinity (Brugnoli and Lauteri 1991). This resulted in reduced P_N, plant productivity, and biomass yield.

The dry mass of shoots was more affected by salinity than that of roots (Table 1). The losses in shoot dry matter gain were 17-59, 12-57, and 29-67 % in Bahar, S7C15, and WSL22, respectively. The reduction in root dry mass gain was only 2-9 %, which agrees with the results of Pardo *et al.* (1998) for tobacco plants. The total plant dry mass after imposing various saline irrigations declined by 16-46, 9-43, and 21-50 % in comparison to control in Bahar, S7C15, and WSL22. Similar observations were reported by Thronton *et al.* (1988) and Brugnoli and Björkman (1992) in certain glycophytes. Our findings indicated that 50 mM NaCl was not severe for biomass yield.

The HI was higher in control plants than in the salinity-treated ones: a continuous decline of HI with applied NaCl concentration was found in all clones (Table 1). The effect was most expressed in the clone WSL22. The trend of HI indicates how effectively these clones of poplar partition dry matter into usable aboveground plant parts (Michael *et al.* 1988) under adverse surrounding of salinity. Furthermore, continuous decline of HI throughout the growth of poplar seedlings under salinity favours lower biomass production.

Our study favours selection of suitable tree species/genotypes before extending poplar large scale plantation in a specific agroclimatic zone; this is essential to achieve desirable plant productivity/afforestation success. There is a large genetic potential based on genetic/clonal variability (Epstein *et al.* 1980) , which can improve plant productivity under changing environmental variables, but it is unrealised because of the need for better adaptation.

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