Characterization of Acadian Peninsula (New-Brunswick) peatland soils to assess their agronomic potential

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Introduction

Some of the many peatlands of New Brunswick (Canada) have been exploited for peat extraction, especially in the Acadian Peninsula where the quality of the peat is exceptional and is used worldwide by the horticultural industry (Lamarche and Daigle, 1999). According to New-Brunswick provincial policy, mined peatlands must be restored as functional wetlands after peat harvesting. Other economic uses of the land may be considered, however, provided that the essential functions of the bog are preserved. Some grasses (reed canary grass - *Phalaris arundinacea*) and perennial tree crops (fast growing willow - *Salix miyabeana*) could be grown in abandoned peatlands (Kuhlman *et al.* 2011), to restore a vegetation cover and provide an economic return.

OBJECTIVE: The objective is to determine the physico-chemical and hydrological properties of three Acadian Peninsula (N.B.) mined peatlands and examine the potential of their soils to withstand perennial added value crops through an initiative of ecological restoration and reclamation.

Material & Methods

The study was conducted on three mined peatland sites in the Acadian Peninsula (Maisonnette, Pigeon Hill and Lamèque, New-Brunswick, Canada). A soil survey was carried out on the three sites in order to update site pedology (figure 1). Hydraulic conductivity and physical and chemical properties of the mineral soil were evaluated. The Lamèque site was chosen to assess soil fertility and potential as growing medium for several crops. Thus, the site was tilled to mix the residual peat (thickness of 15 cm) to the mineral soil layer (figure 2) and samples of this mixture were taken to analyze physical and chemical properties. A small portion of residual peat and mineral mixture was used for a greenhouse trial. Reed canary grass and fast-growing willow were grown. pH was adjusted to 5.5 for willow and 6.5 for reed. Willow was also grown in an unbalanced (pH) sample. An all-purpose commercial peat-based mix (pH = 6.7) was used as the control. Plant lengths and root system quality were determined.

Results & Discussion

Physical characteristics

The granulometric analysis of the three site's mineral soil shows that the texture corresponds to loamy sand, sand and sandy loam (table 1). The estimated density and porosity are average, while the estimated permeability is excellent. The coefficient of available water estimated was sufficient for all soils, except for the Maisonnette site were texture was coarse sand. Physical properties of Lamèque's soil, once tilled, was improved regarding porosity and water content potential. Saturated field soil conductivity is almost near zero for all sites (K_{sat} = 0 to 0.5 cm/h), which indicates that drainage was poor and soils were saturated in late fall. Visual assessment shows that soils had a poor structure and a compacted subsoil layer, which is confirmed by nearby soil association types (Michalica *et al.* 2000). According to their physical characteristics, soils developed under Acadian Peninsula peatlands would need a good tillage and a subsoil drainage system to support the growth and development of various plants and crops.

Chemical characteristics

The natural fertility of the three sites is low, according to their CEC, C/N ratio, organic matter content (O.M.) and pH (table 2). Once mixed with the residual peat layer, the natural fertility of Lamèque's soil was greatly enhanced: its CEC mean value was high as well as its O.M content, although it was still extremely acidic. Our analyses showed that improvements of O.M content through peat addition enables this soil to store cationic nutrients such as potassium, magnesium or calcium, and consequently suggests that additions of minor or major elements would rapidly enhance their overall fertility.

Figure 1. Pedon of subsoils in mined peatlands

Figure 2. Lamèque's mixed soil

Table 1. Physical properties of peatland soils

		Maisonnette	Pigeon Hill	Lamèque	Tilled soil
Texture class		**Sand**	**Loamy sand**	**Sandy loam**	**Sandy loam**
sand	%	87.2	74.8	85.0	82.3 ± 3.7
silt	%	9.6	20.0	7.7	12.2 ± 3.5
clay	%	3.2	5.3	7.3	5.6 ± 1.0
Consistancy		Very friable			Friable
Bulk density*	g/cm³	1.28	1.37	**1.24**	**0.87 ± 0.1**
Total porosity*	%	51.6	48.2	**51.8**	**64.9 ± 3.2**
Permeability*		Good			Good
K_{sat}	cm/h	0 to 0.10	0 to 0.52	0	-
AWC	g water/100g soil	1.7	12.0	11.0	12.7 ± 0.8

K_{sat} :Saturated hydraulic conductivity, AWC :Available water coefficient, *`: Estimated in lab

Table 2. Natural fertility of peatland soils

		Maisonnette	Pigeon Hill	Lamèque	Tilled soil
CEC	meq/100g	5.8	1.3	**11.4**	**21.6 ± 1.4**
O.M.	%	1.28	1.37	**3.1**	**11.5 ± 3.1**
C/N		46.4	23.2	45.0	46.6
pH		3.9	4.3	4.6	4.3 ± 0.1

CEC: Cation exchange capacity, O.M.: Organic matter, EC: Electrical conductivity

Table 3. Chemical properties of peatland soils

		Maisonnette	Pigeon Hill	Lamèque	Tilled soil
Major elements					
Phosphorus	**P**	5	5	**76**	**55 ± 19**
Aluminium	Al	219	213	1895	1353 ± 427
P/Al	%	2.3	2.3	4	4.2 ± 1
Potassium	K	6	7	8	10 ± 1
Calcium	Ca	40	42	66	100 ± 63
Magnesium	Mg	21	16	24	61 ± 15
Total nitrogen	**%**	0.01	0.01	**0.04**	**0.14**
Minor elements					
Boron	B	0.2	0.3	0.5	0.3
Copper	Cu	0.5	0.4	2.1	0.7
Iron	Fe	14	183	194	148
Manganese	Mn	1	1	3	4
Zinc	Zn	0.6	0.6	0.6	0.7

The value of major elements is very low for K, Ca, Mg, and for P, with the exception of Lamèque's soil where P ranges from average to good (table 3). However, high Al content in Lamèque's soil tends to fix P in the soil and limit its bioavailability. Mineral soils are very poor in nitrogen, though nitrogen levels improved for Lamèque's soil (0.14%) after it was tilled. The concentration of minor elements is also very low for Zn, B and Mn. This general low fertility of Acadian Peninsula residual peatland soils can be explained by the paludification of northeastern New-Brunswick bogs. Thus, their use for cultivation would require liming, to reduce Al toxicity and P retention, and the addition of fertilizers with major and minor elements to adjust for crop requirement.

Crop growth tests

The growth tests in soil samples taken from the tilled Lamèque site show that willow grows as well in a slightly limed, unfertilized residual peatland soil, than in an all-purpose commercial peat-based mix. Growth is reduced by 50%, however, when an un-limed peatland soil is used (figure 3).

The reed canary grass grew best in the residual peat substrate than in the control (figure 4). A visual assessment indicates that reed canary grass grown in the residual peatland substrate has a stronger root system and longer shoots than that grown in the control. These results indicate that willow and reed canary grass could potentially be grown in reclaimed peatlands.

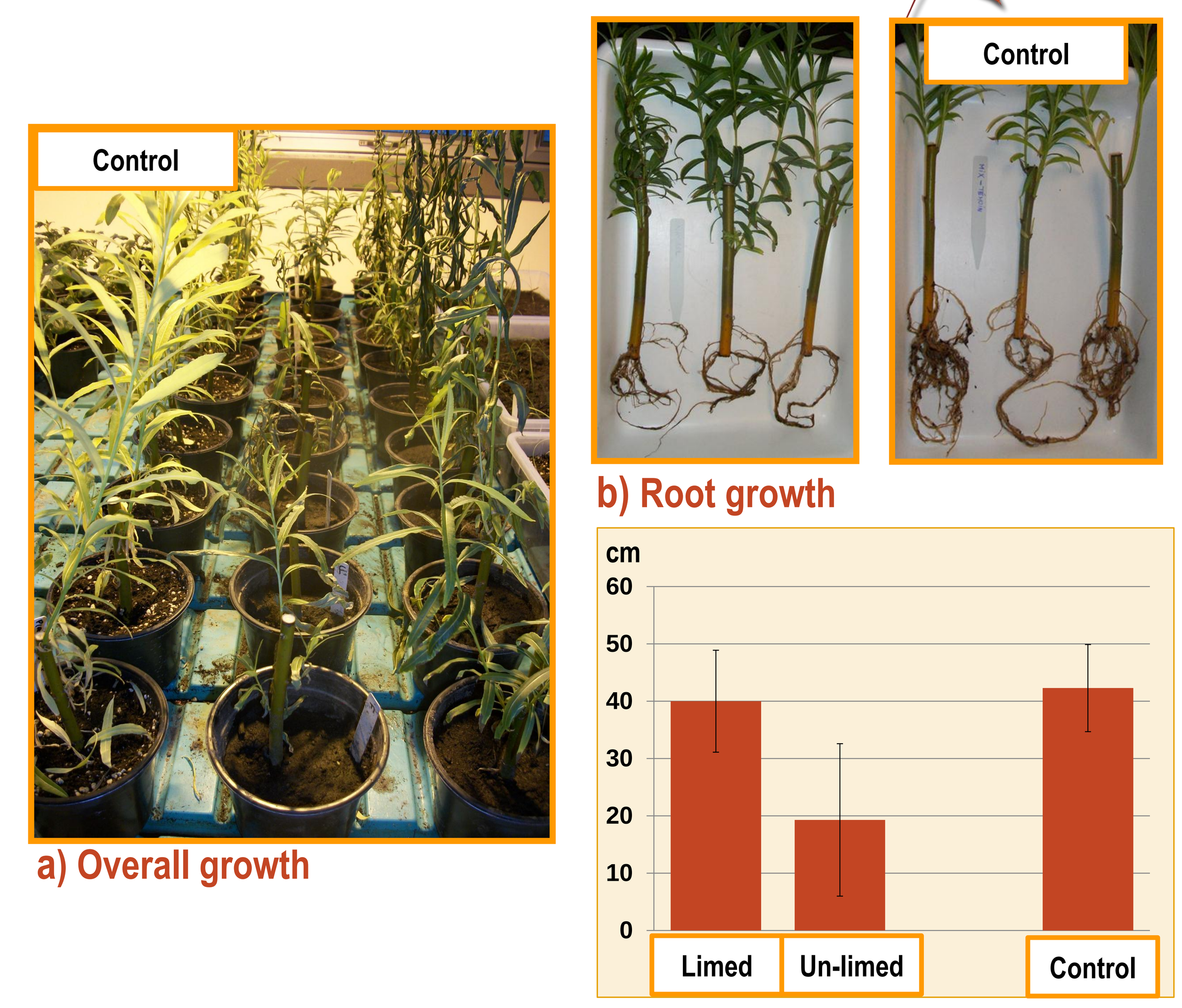

Figure 3. *Salix miyabeana* growth after 8 weeks (n=10)

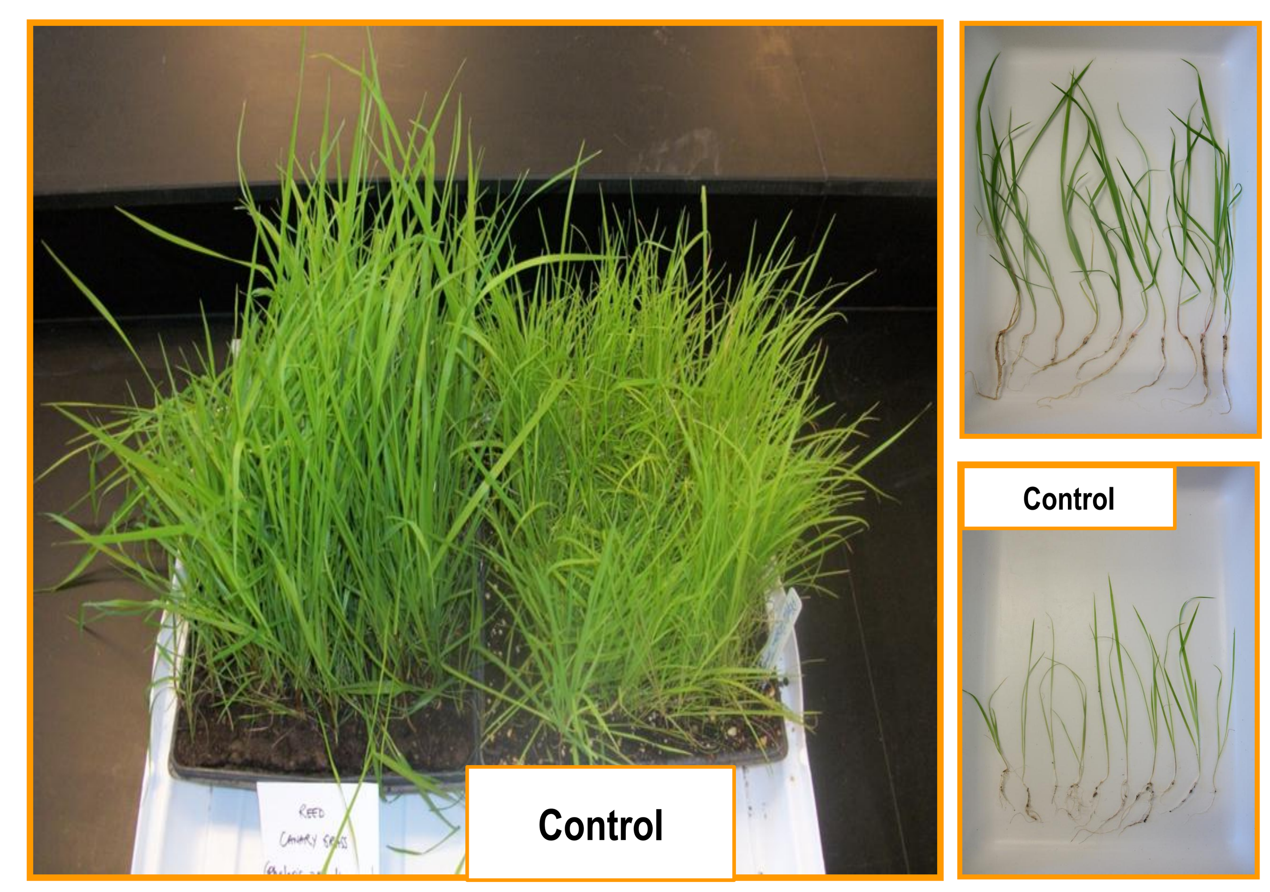

Figure 4. *Phalaris arundinacea* growth after 8 weeks (n=10)

Conclusion

This characterization of residual peatland soils in the Acadian Peninsula shows that once the peat has been mostly extracted, the physico-chemical properties of the mineral soil below may allow the cultivation of bioenergy crops, even with a low fertility level. The fast-growing willow and reed canary grass may be good potential crops for the pedo-climatic conditions prevailing in the peatlands of northeastern New-Brunswick. These crops could be used directly as biofuel (Kuhlman and al. 2011) with minimal prior processing to fulfill the needs in renewable energy of the New-Brunswick peat industry. Thus, further studies regarding their productivity on wet saturated soils should be undertaken.

References

Lamarche, R., Daigle, J. Y. 1999. L'industrie de la tourbe au Nouveau-Brunswick: naissance, développement et perspectives d'avenir. Monographie. Institut Canadien de recherche sur le développement régionale, 88pp.

Kuhlman, T.,Verburg, R., Van Dijk, J. and Drost, N. 2011. Biomass on peat soils : Feasibility of bioenergy production under a climate change scenario. Chap 6 in E.Koomen, J. Borsboom-van Beurden (eds.) Land-Use modelling in planning practice.

Michalica, K.; Rees, Herbert W.; Dillon, M.J.; Loro, P.J.; Toner, P.M.; Donald, R.G.; Parks, J.J. 2000. Soils of the Acadian Peninsula, Gloucester County, New Brunswick. 120 p. + 7 maps.

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