Tree root systems architecture in earth dike

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ABSTRACT

Trees growing on earth dikes generates safety problems and reduces dike durability. Root systems generate internal and external erosion risks which can be important on dikes wooded for a long time. Erosion risks increase with tree age and stand density.

The aim of this study is to analyse root systems characteristics of trees rooted in canal dikes and flood protection dikes. Root systems structure and morphology depend on species and materials.

On various species studied, different types of roots can be observed. Short and long roots are characterized by differences in diameter decrease, branching frequency and inclination. A root typology is determined.

Key words: stump structure, root system architecture, root typology, earth dikes safety

INTRODUCTIONS

Trees growing on earth dike generates safety problems and reduces dike durability. Tree roots in earth dikes generate two types of risks:

- internal erosion witch is related to galleries created by rotten roots in earthfill and also to mechanical action of live roots which can decompact dike materials or destroy masonry protection works or joints;

- and external erosion witch is often related to tree uprooting (during storms for example).

In order to determine the impact of woody root systems on the structure and the durability of dike embankments, it is necessary to analyze root systems characteristics for different tree species.

The objectives are to acquire data about tree root systems in dikes (on 2 types of dikes: canal dikes and flood protection dikes).

The acquisition of knowledge on the structure of woody root systems in dikes - morphology, root network and architecture - requires digging up trees.

METHODS

In order to determine the impact of woody root systems on dike embankments, 100 trees of various species including poplar (*Populus spp.*), willow (*Salix alba*), black locust (*Robinia pseudoacacia*), maple (*Acer spp.*), ash (*Fraxinus excelsior*), oak (*Querqus spp.*), larch (*Larix decidua*) and pine (*Pinus silvestris*) were excavated cautiously with mechanical shovel on 7 sites (Figure 1 and Table 1).

Then manual measurements were carried out on stumps (length, width, depth) and on root architecture (diameter, length, branching, direction and angle of the roots).

A root typology was defined according to the architectural characteristics of measured roots.

RESULTS

Types of dike and trees position affect considerably stump structure and root architecture. Stump structure and volume, root distribution, diameter and length depend on many factors: species, stump age, dike materials (texture, structure, compactness, organic matter content) and water availability.

Stump structure and root architecture are different on canal and flood protection dikes. On canal dikes root systems are composed by few big winding roots compared with flood protection dikes where root systems are composed by many little straight roots.

Root systems are made up of long horizontal roots, of short slanted roots and sometimes of tap roots. These three types of roots have different rates of diameter decrease, branching frequency and angle (Table 2). Robinia and poplar have some big long horizontal roots with a diameter decrease rate of 2%. This rate is about 8% for short roots and 12% for taproot.

DISCUSSIONS

Stump structure and architectural root type influence risks for dikes. For example, risks are higher when big roots cross right through the dike body.

Ideally, no trees should grow on dikes and all new tree growth should be stopped.

However, by killing existing trees, the structure of dike materials changes due to rotting roots, thus creating galleries or heterogeneities leading to internal water erosion.

The recommendation so far is to limit the growth of existing trees but not to kill them. Trees shouldn’t be devitalized if their stumps aren’t removed, materials recompacted and dikes repaired.

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FIGURES

Figure 1: Excavation of a stump on Donzère canal dikes (Green Oak)

Figure 2: Manual measurements on root systems

Figure 3: Different types of roots on Ash: Long Large root (left) and Short Large root (right)

TABLES

Site and Date	Number of trees (100)	Tree species	Type of studies
Rhone canal dyke in Donzère April 2007	3	Oak Poplar	1- Tree root structure observation according to the context 2- Architectural characteristics measurements
Rhone canal dyke in Montélimar May 2007	9	Acacia Oak Poplar	
Rhone canal dyke (downstream embankment) in Lyon July 2007	19	Acacia Ash, Maple Poplar, Oak	1- Tree root structure observation according to the context 2- Architectural characteristics measurements 3- Stumps terrestrial laser scanning
Isere river flood protection dyke in Grenoble April 2008	25	Acacia Ash, Poplar Oak, Willow	1- Tree root structure observation according to the context 2- Architectural characteristics measurements 3- Stumps terrestrial laser scanning 4- Experimentation on root decomposition
Rhone canal dyke in Lyon (upstream embankment) September 2008	14	Alder Ash Maple Dogwood	1- Tree root structure observation according to the context (trees growing on concrete paving protection and rip-rap)
Loire river flood protection dyke in Cosne October 2008	22	Acacia, Ash Poplar, Oak Maple, Willow	1- Tree root structure observation according to the context 2- Architectural characteristics measurements 3- Dendrology analyses on roots 4- Electrical measurements on roots
Casterino river dam dyke in Casterino June 2009	8	Larch Sylvestris pine	1- Tree root structure observation according to the context 2- Architectural characteristics measurements 3- Dendrology analyses on roots 4- Experimentation on root decomposition

Table 1: Sites, number and methods of studied root systems

Type	Inclination	Branching	Morphology	Top diameter	Root lenght	Order
T	V	variable	Conical	≥ 5 cm	> 50 cm	1
ST	V / O			< 5 cm	< 1m	1 ; 2
LL	H	few branching	Linear	≥ 5 cm	> 2 m	1 ; 2
LM	H			]1 ; 5[	> 1m	1 ; 2 ; 3 ; 4
LT	H			]0,3 ; 1]	> 50 cm	2 ; 3 ; 4
SL	H / O	many branching	Conical	≥ 5 cm	< 2 m	1 ; 2
SM	H / O			]1 ; 5[	< 1 m	1 ; 2 ; 3 ; 4
ST	H / O			]0,3 ; 1]	< 50 cm	2 ; 3 ; 4

T: Taproot, ST: Secondary Taproot, LL/M/T : Long Large / Medium / Thin, SL/M/T: Short Large / Medium / Thin

Table 2: Root typology parameters