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Development of Riparian Tree Roots in Compacted Coarse Gravel Mixtures

Analysis of Alternative Measures to Decrease Asphalt Damages caused by Tree Roots

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Fig. 1: Experimental area before surface biomass harvest (August, 2016) (1). Subplots of boxes (50x33x13 cm) and planting strips (16x16x16 cm) for below ground biomass collection (2). Uncovered boxes before root biomass extraction (3). Cutting with roots in planting strip (4). Fine roots in coarse gravel mixture (5). Medium and large roots in coarse gravel mixture (6).

Background

Uneven roads and ripped asphalt layers are a common problem for infrequently used roads and cycle/pedestrian paths. The reasons for this issue are rather shallow road beds and a thin paved top layer combined with the presence of trees and shrubs. Attracted by the moisture underneath the pavement due to condensation water and the insufficient drainage effects of compacted base material, the roots often penetrate the small space between top layer and sublayer. During secondary growth, roots gain in root diameter and raise the top layer until the asphalt surface is torn apart. This phenomenon causes high repairing costs and can lead to accidents and injuries. The former towpaths along the Danube, which are now used as multi-use paths, are prone to this issue: the riparian vegetation along the roads causes a severe problem for maintaining the service and cycling paths. A possible solution is filling the road bed with a mixture of crushed coarse gravel to enhance the drainage and create an undesirable environment for root growth.

Methodology

A small scale field experiment has been set up as shown in Figure 1 and 2. Six wooden boxes with the dimensions 1,5x1x0,5 m were filled with different sized coarse gravel mixtures (0/32, 08/32, 16/32, 0/63, 16/63 and hydraulic stabilized 08/32 hs) to examine the short and long term effects of the substrates as base material for road sublayers. To simulate the effects of condensation water, the substrates were covered by a 0,1m thick layer of concrete. Poplar and willow cuttings were planted along the boxes, separated from the gravel by differently sized steel meshes and a geotextile layer. This setup allows the roots to grow into the gravel mixtures, but separates the soil and the substrate layer. The arrangement was repeated three times. This enables the examination of short and long term effects, since the first biomass extraction was undertaken after one vegetation period in 2015, the second extraction in 2016 and the third one will be carried out in three years. For the root extraction, the boxes were split into three even sized horizontal levels and three vertical columns, which resulted in 27 small subplots, as shown in Figure 1 (2). This allows a spatial analysis of the root distribution. Each plot was examined separately by sieving the gravel and collecting the root biomass. Subsequently, the biomass was dried and weighed. A fleece separated the upper and lower base course, which increased the moisture level because the water could not drain off freely. This caused an enhanced root growth close to the bottom of the boxes. Therefore, the root biomass data was analyzed for the first two levels to exclude side effects.

Results

The poplar and willow cuttings developed well over the last vegetation period and the surface and underground biomass has mostly doubled compared to the amount of biomass collected after the first vegetation period. The occurrence of root biomass varied greatly from substrate to substrate, as shown in Figure 3 (1). We found the smallest amount of root biomass in the 08/32 hs gravel mixture (84g) and the highest amount within the 16/63 mixture (225g). Nevertheless, when we analyzed the biomass data in relation to the amount of root biomass in the planting strip in front of the boxes, the lowest share of biomass was found in the mixtures 08/32 hs, 0/32 and 16/63 (Fig. 3 (2)). The spatial distribution of the root biomass demonstrated that root growth occurred mostly in the top levels and close to the planting strip (Fig. 4). Especially in the 16/63 mixture, the biomass has accumulated in level three and column one. To examine the mixtures without the influence of the walls or bottom of the box, we compared the biomass data of the central pillar of each box related to the total absolute soil root biomass. The results show a distinct lower quantity of biomass in the mixtures 08/32 hs and 16/32, followed by 16/63 and 0/32. Comparing the data from 2015 and from 2016 (Fig. 5, Tab. 1), the 08/32 hs biomass data increased the least. The 16/63 biomass increase occurred mostly close to the bottom of the box, which can be neglected because of the high moisture level close to the fleece layer. The 0/32 and 16/32 mixture biomass increased the most.

The analyses indicate that the least biomass was found in the hydraulic stabilized gravel mixture and the roots developed little compared to the other gravel mixtures, which is optimal for the use as road bed filling. Nevertheless, the long term effects are still unknown and recommendations need to be handled with care until these are examined after the extraction of the last box set of the field experiment.

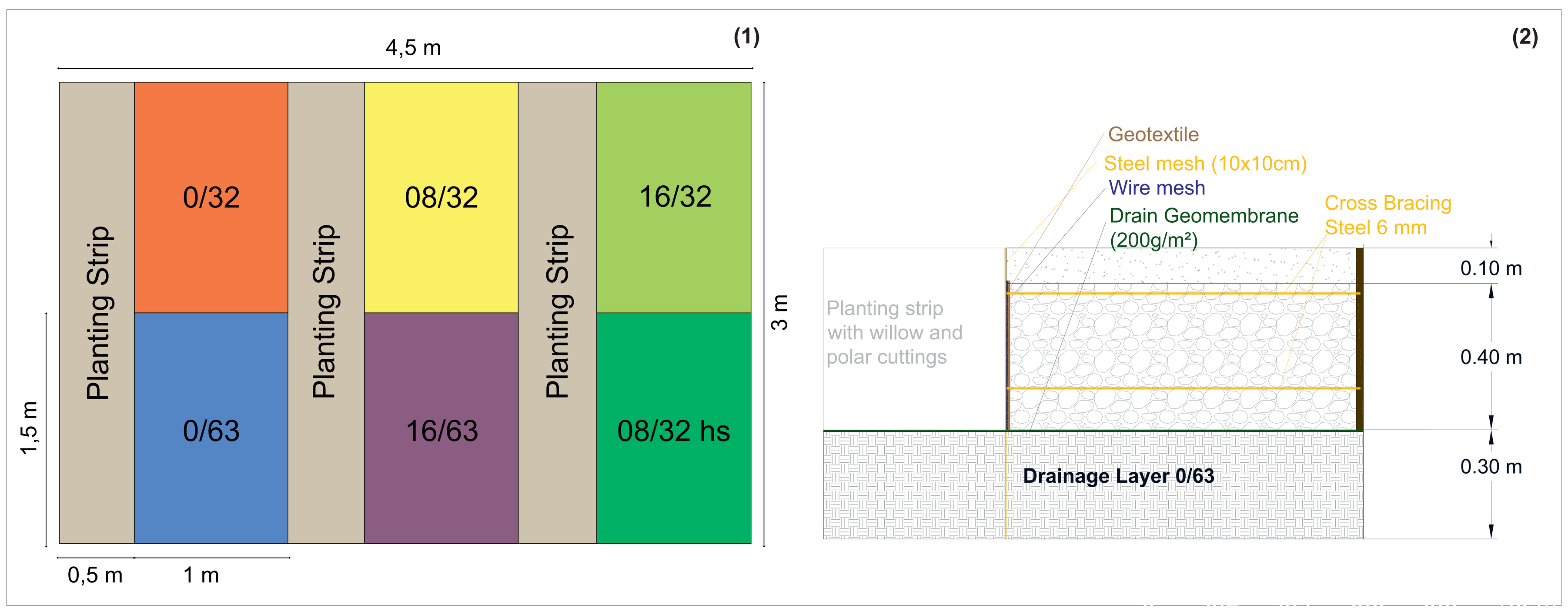

Fig. 2: Schematic setup of field experiment (1) and cross section of the boxes (2).

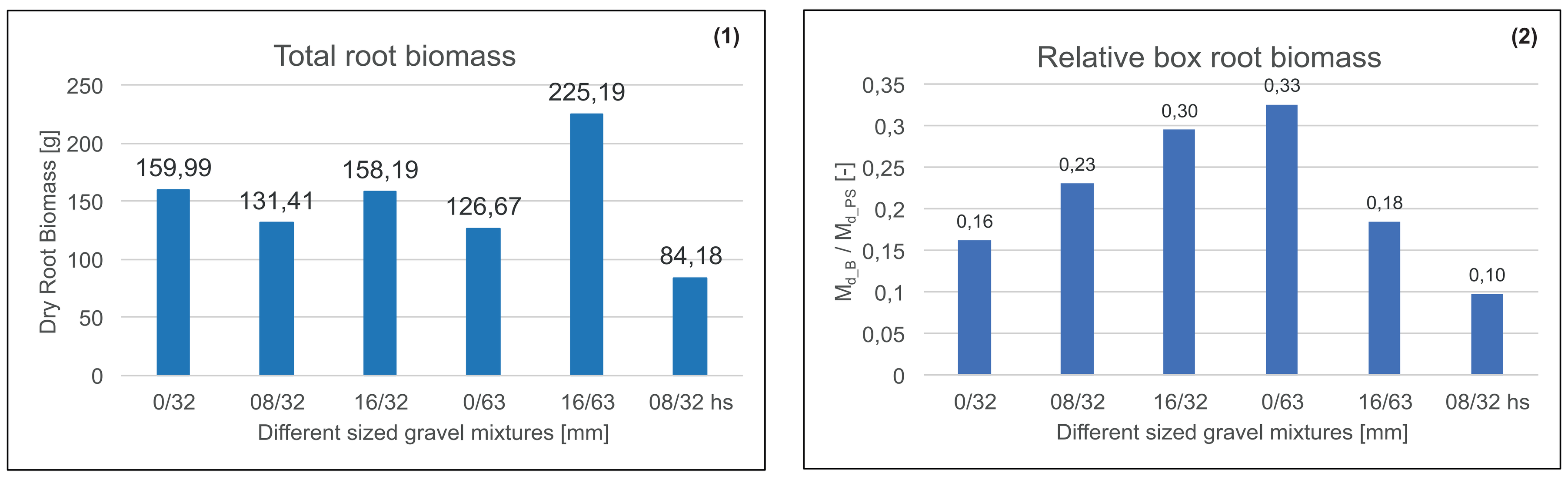

Fig. 3: Total dry root biomass of boxes (1) and relative dry root biomass of boxes in relation to dry root biomass found in planting strip (2).

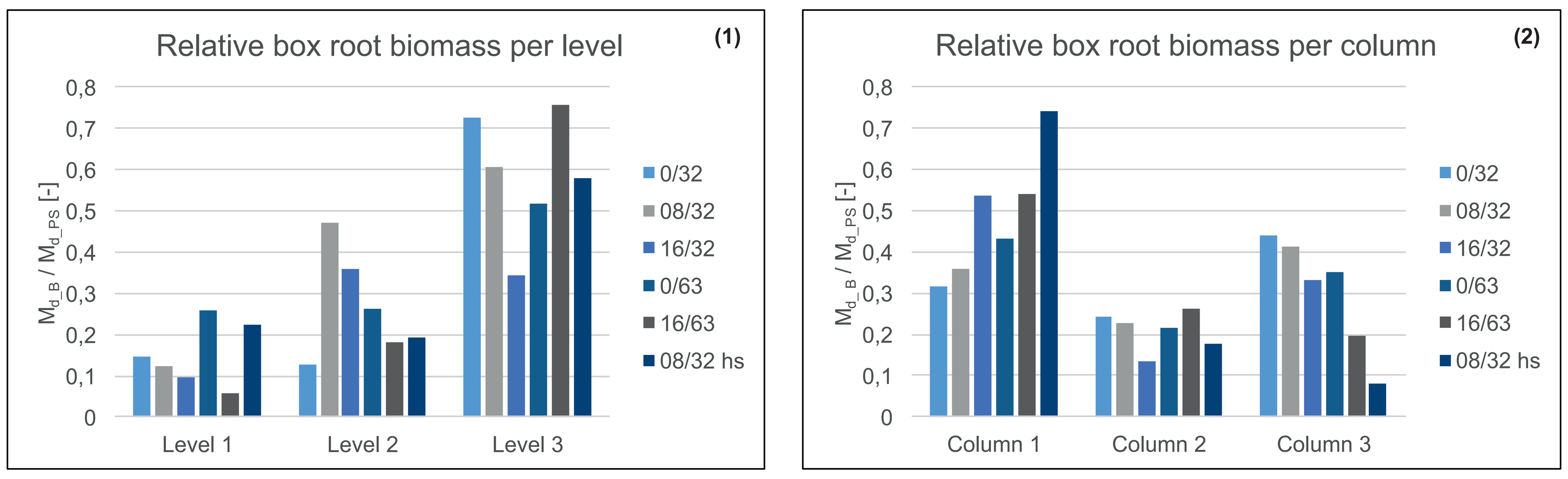

Fig. 4: Relative dry root biomass of boxes according to levels (1). Relative dry root biomass of boxes according to columns (2).

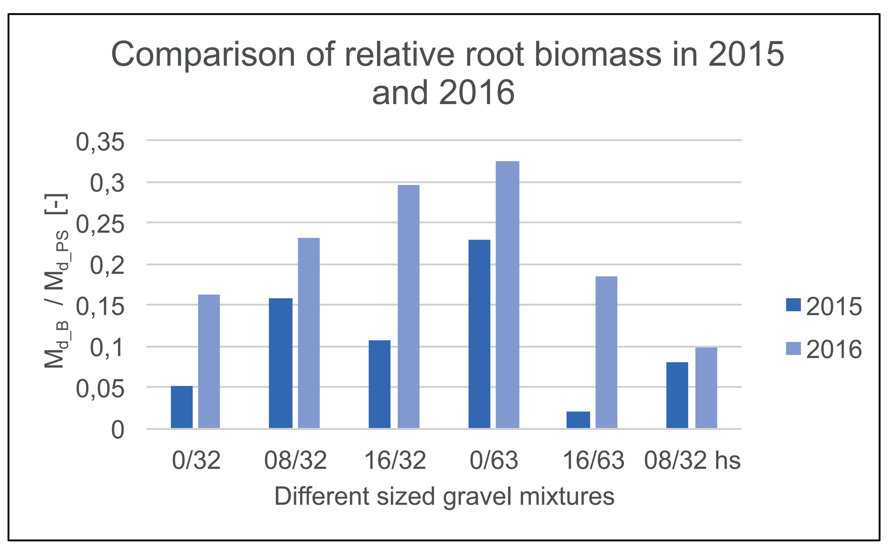

Fig. 5: Comparison of relative dry root biomass of boxes extracted in 2015 and in 2016.

Table 1 (1)		0/32	08/32	16/32	0/63	16/63	08/32 hs
Total Amount [g]	2015	16,84	48,26	50,48	29,91	19,45	25,48
	2016	159,99	158,19	126,67	131,41	225,19	84,18
	Difference	143,15	109,93	76,19	101,50	205,74	58,70
Level 1 [g]	2015	2,61	11,41	9,61	7,37	1,15	6,31
	2016	23,59	16,16	15,56	32,59	13,36	18,86
	Difference	20,98	4,75	5,95	25,22	12,21	12,55
Level 2 [g]	2015	4,32	13,80	5,88	10,40	1,48	6,21
	2016	20,32	62,13	56,71	33,16	40,98	16,40
	Difference	16,00	48,33	50,83	22,76	39,50	10,19
Level 3 [g]	2015	9,91	23,05	34,99	12,14	16,82	12,96
	2016	116,08	79,90	54,40	65,66	170,85	48,92
	Difference	106,17	56,85	19,41	53,52	154,03	35,96

Table 1 (2)		0/32	08/32	16/32	0/63	16/63	08/32 hs
Total Amount [-]	2015	0,05	0,16	0,11	0,23	0,02	0,08
	2016	0,16	0,23	0,30	0,33	0,18	0,10
Level 1 [-]	2015	0,04	0,13	0,13	0,19	0,02	0,10
	2016	0,22	0,15	0,14	0,46	0,13	0,16
Level 2 [-]	2015	0,06	0,19	0,08	0,27	0,02	0,07
	2016	0,12	0,27	0,43	0,25	0,21	0,07
Level 3 [-]	2015	0,09	0,23	0,22	0,11	0,15	0,10
	2016	0,55	0,41	0,27	0,19	0,54	0,15

Tab. 1: Comparison of dry root biomass extracted in 2015 and 2016: total dry root biomass found in boxes (1), relative dry root biomass related to dry root biomass found in planting strip (2).

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