SOIL Discuss., 2, C133–C138, 2015
www.soil-discuss.net/2/C133/2015/

SOIL Discussions Open Access

Interactive comment on "Can we manipulate root system architecture to control soil erosion?" *by* A. Ola et al.

Anonymous Referee #2

Received and published: 9 May 2015

General comments This paper is not of a common type, it is not an experimental paper nor solely a review, but a sort of review with leads to a main idea, a main hypotheses which is not tested experimentally or by modelling. I would have preferred a classical synthesis or an experimental paper.

It is a review about effect of plant roots (not only architecture) on soil properties and hydrology regarding erosion, and the main hypothesis is that, as plants can form dense mats of roots at the soil surface which may block soil pores and therefore limit infiltration, deeper placement of fertilizer would decrease soil erosion through concentrated flow by inducing a proliferation of fine and thin roots in deeper horizons (at 10 cm depth ? we don't know) at the expense of shallow roots. The title do therefore not really correspond to the content.

Moreover, the most recent review I know on this subject is not cited in this manuscript! : “The role of fine and coarse roots in shallow slope stability and soil erosion control with a focus on root system architecture: a review (2007) Bert Reubens Jean Poesen Frederic Danjon Guy Geudens Bart Muys Trees 21:385–402 DOI 10.1007/s00468-007-0132-4 “ It was cited 97 times, it is therefore probably not a bad paper, I’m therefore very surprised that it was not cited in the manuscript. There is another synthesis about erosion by Knapen et al 2007, cited in the manuscript. The present manuscript address more precisely each effect of roots (not only root architecture) on erosion. Among the 88 papers cited in the manuscript, only 15 have been published after 2007. This means that only few papers were published the 8 last years on the topic erosion and root architecture, and more generally, the role of root architecture on erosion is not very well known.

There is a big problem in this paper, it is difficult to understand how the main hypothesis is built. It may come from Archer et al. (2002), wrongly cited p271 line16 : Archer et al. did not study lolium perenne and agrostis capillaris but only refer page 537 to Morgan et al. (2005), “lolium perenne and agrostis capillaris form fibrous and rhizomous mats, respectively, at shallow depth, and have low hydraulic conductivity. Densely growing fibrous and rhizomous roots could occupy more pore space at the soil surface , reducing macropore space available for water movement”. From what I know, grazing lands in fairly wet zones are not so much prone to erosion if the plant cover is continuous, not disturbed by trampling of hikers, including natural zones like mountain pastures. Because hydraulic conductivity is not the sole parameter determining erosion rate. Annual crops land are much more prone to erosion, and i’m not convinced that wheat or hordeum or zea can really block heavily water infiltration by the shallow root mat they could form at the end of the growing season. Moreover, the hypothesis rely also on work of Drew and co-workers on annuals crops growing short time in well watered artificial and oxygenated media showing that fine roots proliferate in the area where nutrients are more abundant. I’m not sure grass species such as lolium perenne and agrostis capillaris will really completely change their architectural model by setting most

SOIL
2, C133–C138, 2015

of their fine and thin roots at 20 cm depth if fertilizer is provided there. Additionally, the role of grass is contradictory, p268 lolium perenne is cited as decreasing drastically erosion. Or line 12 page 273 “fibrous root systems being more effective in reinforcing soils than tap rooting species”. Rooting in the soil is much more complex than the rhizotron 2D experiments on young plants and artificial media from Drew. Rooting is dynamic, there is and interaction and feed-back through depletion between root growth and water content of the soil (work of e.g. Glyn Bengough), and also with biomechanics (last paper on interaction between slope and mechanical perturbation of shoot : Danjon F, Khuder H, Stokes A (2013) Deep Phenotyping of Coarse Root Architecture in R. pseudoacacia Reveals That Tree Root System Plasticity Is Confined within Its Architectural Model. PLoS ONE 8(12): e83548. doi:10.1371/journal.pone.0083548). Moreover, water content and root distribution are dynamic, especially in annual crops. Reading the manuscript, I conclude that there are certainly much more way to decrease erosion rate in slopes covered with natural vegetation, forests, perennial or annual crop by manipulating root architecture, it is certainly much more easier by using genetic variability, at the species, provenance or variety level, favouring for example mixtures of shrubs and grasses.

It is not clear if this paper is only about erosion or also about other soil mass movement in sloping ground, in the summary for example you speak about “structural failure at the shear plane”. The role of root tensile strength in soil erodibility is not clear, it should be better explained (line 4 page 269). As erosion and shallow landslides are linked, it may be more easy to treat both in a synthesis. Moreover, the role of root architecture in erosion depends upon the type of erosion, the different categories of erosion are not sufficiently explained, and the link with root architecture is not clear, schemes and table like the scheme P550 in Archer et al. (2002) are really missing in this synthesis. You should have more tables/schemes summarising what you are dealing with. In the same way, the manuscript deals mainly with annuals crops, but there are several references to forest and to natural areas. You should better define which ecosystems you will address, mainly on annual crop plants or all plants.

SOIL
2, C133–C138, 2015

Finally, root architecture is much more than just the density of fine roots, its first an overall root structure, with a root system composed of root types having each its properties, its tropisms (see (Barthélémy D, Caraglio Y 2007 Plant architecture: A dynamic, multilevel and comprehensive approach to plant form, structure and ontogeny Annals of Botany 99:375-407 // Danjon F, Reubens B 2008 Assessing and analyzing 3D architecture of woody root systems, a review of methods and applications in tree and soil stability, resource acquisition and allocation. Plant and Soil 303:1-34. DOI: 10.1007/s11104-007-9470-7 or Lynch works - e.g. Basu et al. Plant Physiology, April 2011, Vol. 155, pp. 2056–2065). And R. W. ZOBEL & Y. WAISEL 2010 A plant root system architectural taxonomy: A framework for root nomenclature. Plant Biosystems Vol. 144, No. 2, pp. 507–512 . And root architecture in largely influenced by the soil properties, but some characteristics are plastic, other characteristics not [e.g. taproot is vertical and shallow laterals follow the soil surface]. And root systems are especially influenced by soil geometry [slope], with and interaction with mechanical perturbations of shoots, see Danjon et al. 2013).

in general the manuscript has a fairly fuzzy structure, with no clear synthesis of each section, you write for example a 15 lines paragraph about one specific root parameter (rld) whereas other root parameter exist (RAR biomass, RLD, angle to vertical, branching parameters). A subchapter about all usable root parameter would be needed. Moreover, several parts of the manuscript are only a sort of collection of references which can yield contradictory results, and not a synthesis trying to explain what's happening, why the results are contradictory;

You should mention fauna associated to plant, especially earthworms, (halett) providing additional structural improvement to soils. e.g. earthworms and termites on runoff and erosion in a tropical steep slope fallow in Vietnam: A rainfall simulation experiment Jouquet, Pascal; Janeau, Jean-Louis; Pisano, Alexandro; et al. 2012 APPLIED SOIL ECOLOGYÂăÂăVolume: 61 ÂăPages: 161-168

line 13 page 277: water uptake depends on the distribution of water in the profile,

SOIL
2, C133–C138, 2015

and there is often strong interaction between fine root growth and water availability, and water depletionÂă(bengough et al.Âă: in hordeum, water depletion = increase soil impedance = restrict growth.

specific comments line 11 page 268: I do not understand this sentence, relationship between water interception of aerial parts and soil shear strength is unclear for me. line 21-22 page 268: is it for aerial ÂńÂăbiomassÂăÂż. variables for roots and aerial parts have probably not the same dimensions, therefore it is difficult to compare percentages. line 19 page 272: RSA is not just the 3D deployment of roots, see reubens et al. 2007 (page389) barthélémy and caraglio or malamy : its topology and geometry, moreover, each species has an architectural model, and grow several type of roots having each its own properties, for example geotropism or definite growth; line 26 page 272: coarse root are mainly responsible for anchorage (mechanics) and water and nutrient transport. line 26 page 273: exponential increase only below ca. 2 mm diameter line 19 page 272: you should divide this chapter 3 in two chapters, (a) root system architecture and erosion, (b) manipulation of root architecture. line 10 page 274: in the few last years, there were number of papers on high throughput phenotyping of root systems to assess genetic variability, including many studies in artificial media, but also in situ, in the field measurements ("shovelomics" - Shovelomics: high throughput phenotyping of maize (Zea mays L.) root architecture in the field Samuel Trachsel & Shawn M. Kaeppler & Kathleen M. Brown & Jonathan P. Lynch 2011 Plant Soil 341:75–87 . with new imaging techniques (e.g. Galkovskyi et al. BMC Plant Biology 2012, 12:116). line 13 page 279: I suggest removing the sentence starting wih "consequently": plants organs have allometric relationship based on the function of each organ. The three main function of coarse root are anchorage, transport and storage of reserves which are compulsory for shoot growth. introduction is ok up to line 18 page 268, after that, most of the text should go in the next chapters, leaving only a few sentences explaining the topic treated in the paper. fig 1 : the role of root as barriers, on soil surface roughness is not in the scheme. You have 5 columns in this scheme, it is not clear why - "exudates" is in column 2 an "soil particles" in 3, ok, - but you should have "fine and

SOIL

2, C133–C138, 2015

coarse roots” in colum 2 and “water uptake”, “enhancement of infiltration capacity” and “soil mechanical reinforcement” in column 3. and a column 4 with “enhances infiltration rate” and “reduces surface runoff”

technical corrections line 12 & 13 page 266: I would not use “we clearly demonstrate”, because it is not an experimental paper, and you cannot say that all plants increases lateral root growth in nutrient patches. line 9 & 12 page 268Âă: repetition of a sentence about OM content line 16 page 272: ÂńÂăinfluenced byÂăÂż many other root root system properties influence soil reinforcement

---

Interactive comment on SOIL Discuss., 2, 265, 2015.

SOIL

2, C133–C138, 2015

Interactive Comment