Dear anonymous reviewer,

Thank you for your time, valued suggestions and remarks on our manuscript. However, there are a few points we would like to comment on:

1. Abstract p 266, l 15: “at the soil surface dense root mats of roots may block soil pores thereby limiting infiltration, enhancing runoff and thus erosion”. This suggests that a dense root mat in the topsoil will increase erosion rates while several studies showed that dense roots mats decrease the amount of soil erosion rates (e.g. De Baets, S., Poesen, J. (2010). Empirical models for predicting the erosion-reducing effects of plant roots during concentrated flow. Geomorphology 118: 425-432). So this statement is a bit contradictory with the existing literature on roots effects on soil erosion in the topsoil.

   It is important to consider that concentrated flow erosion is an incisive process which starts with the development of small rills at the soil surface which could develop into large gullies. Therefore it is important to have a dense root mat at the soil surface. Based on the plant species considered the amount of roots decreases with soil depth. Therefore the manipulation of roots at greater depth and their proliferation will indeed protect the subsurface soil when the topsoil is removed by soil erosion processes.

   The effect of different rooting patterns remains largely unproved. Gyssels and Poesen (2003) do state: …depend on root type and their spatial distribution, as suggested by a study of Dissmeyer and Foster (1985). These authors show that erosion rates decline exponentially with an increase in surface soil occupied by fine roots, and that this effect is more pronounced in the case of fibrous lateral roots. , and Gyssels et al. (2005) state, erosion by concentrated flow of species with a shallow but dense network (e.g., meadows) will be larger than the effects of deep rooted species (e.g., deciduous forest).‘ However, the evidence base appears to be rather weak – Just the paper of Dissmeyer and Foster. The referee also misses the point that we are refering to the hydrological effect of dense root systems in the topsoil, which has not been determined experimentally(saturated/unsaturated hydraulic conductivity, infiltration rate etc.) in many of these studies (including De Baets and Poesen, 2010, rather than erosion. It should be emphasized, that the root effect may vary depending on the response of the plant species to localized nutrient availability (i.e.compensatory growth versus overall increase in rooting depth, resulting in different root length densities present in the topsoil as well as in the subsoil).

2. p 268, l 6: “: : : vegetation modifies intrinsic soil properties: : :” which is definitely true, however these are ‘mainly’ the result from the root effects on the soil properties which is also highlighted in Figure 1. But these are already discussed in the next section.

   The above ground cover modifies the same intrinsic soil properties as the root system, but some mechanisms differ (reduced overland flow velocities, reductions of raindrop impact, interception of rainfall, waterloss from leaves etc.). Also, at this stage of the paper, we were not talking about the magnitude of the effect associated with either below- or above ground biomass.

3. I was wondering why only RLD is mentioned while the most frequent used root parameter within erosion studies (concentrated flow erosion) is root density.

   Root density (RD) is the dry living root mass divided by the volume of the root permeated soil sample and may therefore (unlike RLD, which considers the length of the roots) (De Baets et al., 2006) not be the best indicator for the occupation of soil by roots (Bauhus and Messier, 1999; De Baets et al., 2006, De Baets et al., 2007). In *addition, after testing 10 root variables (including RLD and RD) potentially influencing concentrated flow erosion rates, RLD was found to be indirectly linked to soil erosion rates, whereas RD is not sufficient to describe the effectiveness of a species in erosion control (Burylo et al., 2012), although RD may be used when biomass is assessed according to root diameter classes (Bolte and Villanueva 2006; De Baets et al., 2007). However, in the context of this manuscript RLD may still be more appropriate, as C invested in root length (assuming constant tissue density) contributes more towards root surface area (i.e. soil resource exploitation) than C invested in root diameter (Bauhus and Messier, 1999). Moreover, RD is not a root architectural trait (Bauhaus and Messier, 1999; Bolte and Vilanueva, 2006; De Baets et al, 2007).*

<u>Additional References:</u>

Bauhus, J. and Messier, C. (1999). Soil exploitation strategies of fine roots in different tree species of the southern boreal forest of eastern Canada. Can. J. For. Res. 29: 260–273.

Bolte, A. and Villanueva, I. (2006) Interspecific competition impacts on the morphology and distribution of fine roots in European beech (Fagus sylvatica L.) and Norway spruce (Picea abies (L.) Karst.). Eur J Forest Res, 125: 15–26.

Reviewer 2 makes a number of interesting observations which we will take into account in the revised version of the paper. In this response we are dealing with the comments, where we feel further clarification may be needed.

1. It is a review about effect of plant roots (not only architecture) on soil properties andhydrology regarding erosion, and the main hypothesis is that, as plants can form densemats 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.

   The reviewer's point here seems to be that the title is not a clear indicator of the paper's content. On reflection we agree that it may indicate an experimental rather than a 'progress' style paper. Therefore we have changed the title to 'Is there potential to manipulate root system architecture to control erosion?'

2. 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.

   We are aware of this paper, but we did not cite it because of its focus on woody roots of trees, while our manuscript focuses on arable land, as mentioned in the introduction. However, we do agree that it is an important paper with some general information about root system architecture, that our readers may be interested in, so we will cite it in the revised paper.

   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.

   The focus of our manuscript is arable land and thus, mainly annual crops. Occasionally we may have referred to other plants, which should be acceptable depending on the point to be made e.g. studies using grass roots to demonstrate that roots do contribute to the erosion reducing effect associated with vegetative covers (page 268). It is also worth noting that according to the definition by FAO arable land may also refer to temporary pastures (Ramankutty, N. and Foley, J.A. (1999). Estimating historical changes in global land cover: Croplands from 1700 to 1992, Global Geochemical Cycles, 13, 997-1027). Nevertheless, we will reassess the use of these examples during the revision.

3. 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) "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.

We found the reviewers comment a little unclear. We will take a careful look at how we develop our hypothesis in the revised paper, but we are not really clear what point is being made.

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.

There is evidence (Mannering and Johnson, 1969 in Archer et al. 2002) that roots of some crop species (Zea mays and Glycine max) initially block soil pores and flow paths are created upon decomposition of the roots towards 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 of their fine and thin roots at 20 cm depth if fertilizer is provided there.

The focus of our paper is arable crops. However, several studies reported proliferation of roots of grasses in nutrient enriched zones including: Fransen, B.; de Kroon, H. and Berendse, F. (1998). Root morphological plasticity and nutrient acquisition of perennial grass species from habitats of different nutrient availability, Oecologia, 115, 351 – 358.

4. 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.

    We completely agree and we have drawn our examples form a wide range of work, discussing studies based on lab experiments (i.e. rhizotrons, artificial media etc.) and field experiments (page 276 line 26).

5. 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.

    The reviewer may be correct, but we are not principly concernered with forested landscapes. Rather the focus of our review is arable agriculture and mixtures of shrubs and grasses are not really suitable in monoculture agricultural systems. Furthermore, we discussed the possibility to specifically select and breed for plant traits to reduce soil erosion rates (page 274 line 10).

6. … 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.

   We focused on RLD as it has been frequently used in soil erosion studies (concentrated flow erosion). For further details please see reply to Comment #3 from Referee 1.