

## ***Interactive comment on “The root economics spectrum: divergence of absorptive root strategies with root diameter” by D. Kong et al.***

**D. Kong et al.**

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**General comments** This is an interesting study on the relationships between root diameter and root strategies for resource acquisition. This study is based on seven contrasting tree species from tropical and subtropical forest, and a range of root traits to test (1) the influence of root diameter on the root economic spectrum and (2) the influence of root branch order on root C and N fractions. The gradient of plant trait variation, called economic spectrum, has been found world-wide describing the existence of a fundamental tradeoff between acquisition and conservation of resources in plant species. However, our knowledge of below-ground trait variation and their economics remains limited and inconsistent (Chen et al., 2013; Bardgett et al., 2014; Poorter et al., 2014; Reich, 2014). Consequently, the aim of this study is very relevant. But the

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authors only used 7 seven three species from tropical and subtropical forests, which is inadequate and quite ambitious to extent this study to the root economic spectrum as indicated in the title. The choice of plant species and root traits are justified but this study will gain in interest with more vegetation types to test the root economic spectrum as announced by the title. More chemical traits implied in root absorption would have been appreciated to test the hypothesis and to gain more insight of root absorption strategies for nutrient capture as expected. The authors wanted to demonstrate the importance of the cortex and epidermis thickness in the root absorption strategy, which seem to be an important root trait for future research in root ecophysiology. Although this study is interesting, it does not correspond to the title. This manuscript is well written but some more proofreading would have been appreciated to avoid few mistakes. Consequently, some parts should be rewrite and correct to improve the quality of the manuscript.

**Response:** The authors appreciate these pertinent comments of this manuscript. The topic of this study, root economics spectrum, is an important area in plant ecology while with competing perspectives. Results of this study and a reanalysis of a previous study with more species included seem to support our idea for the root economics spectrum in absorptive roots of different diameter groups. The results may be instructive for settling down the emerging controversy on the existence of root economics spectrum. However, as the reviewers concerned, it is a bit ambitious to test our idea of root economics spectrum using only a few plant species. The title seems too big and should be changed accordingly. In this version, we follow the suggestion and use a new title, “Divergence of ecological strategies with root diameter: a potentially new view for root economics spectrum in absorptive roots”. We feel this title more instructive rather than definitive and hence suitable for this study. Further, we think that our study is a valuable trial but not the final conclusion on root economics spectrum. The new view proposed here is open for further test in many other species and can arouse more interest in ecologists and stimulating more extensive work in this regard. We also add this information in the revision version.

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Specific comments Page 13043, line 6 : It would have been appreciated to read more details on the studied vegetation in the abstract. Could the authors specify which kind of plant species are considered in this study and where they come from ?

Response: We have added the information in the revised version.

Introduction is clear but few references are missing in the 'Reference' section, while more references would have been appreciated to justify the choice of root traits.

Response: We have supplied some more important and latest reference on the root traits, i.e. Roumet et al. 2006, Bardgett 2014, Eissenstat et al. 2015.

Material and Methods are too concise and sometimes informal. Some parts of the 'Material and Methods' section should be rewrite to improve the clarity of the work realized.

Response: We note that some parts of the "Material and Methods" are too few. As the reviewers concerned, we have supplied more information in corresponding section. We are grateful for reminding of the missing information. For details of the information, see the revised version with tracked marks.

Methods use to separate thin and thick roots should be better explained and easy to reproduce to gain in interest and to ensure the repeatability of this work among studies.

Response: In the revised version, we have made a great revision for the method separating thin and thick absorptive roots. We also give the detailed response in another following question (see the latter part of this response letter).

In addition, some important details are missing to gain in clarity on the representativeness of the root subsamples used for root trait measurements.

Response: We feel that the reviewer may concern about procedure for root chemical measurements. In our study, the root samples were ground not by hand but by an automatic mill (ZM200, Retsch, Germany) and well mixed for homogeneity before chemical

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measurements. We have added this information in the new version of the manuscript.

In addition, I suggest to use the passive form and remove few parts of the 'Statistical analysis' paragraph to the Results section to improve the quality of the text.

Response: We follow this suggestion and use the passive form in the section of "Statistical analysis". However, the few parts in this section were not removed to the "Results" section. We feel that these parts just present details of the methods in statistical analysis and our arguments for employing such analyses. These are not the real results of the data analyses. Anyway, we appreciate the reviewer for this comment.

Page 13046, line 22: Could the author specify the root mass or fraction of subsample collected to gain more insight of the subsample representativeness.

Response: We appreciate the reminding of details for preparing root samples before chemical measurements. We admit that we have not measured exactly the root mass for chemical analyses. We feel that the reviewer may concern that the root samples were ground by hand and thus they were not fine and homogeneous enough for chemical measurements. In our study, the root samples were ground not by hand but by an automatic mill (ZM200, Retsch, Germany) and well mixed for homogeneity before chemical measurements. We have added the information in the revised version.

Page 13047, line 8: It is very surprising to measure the root length with a tape whereas high efficient image software would have been more precise to analyses the root length and the root diameter. Could the authors justify this choice?

Response: The authors thank for the suggestion of "high efficient image software" method for root length measurements. In this study, the tape was not used for all the root length but for relative longer roots. For relative short roots, we used a stereomicroscope with an ocular micrometer ( $\pm 0.025$  mm). We have added this information in this corresponding sentence. The stereomicroscope or tape method is also a convenient way for measuring root length and have been used in previously, i.e. Guo et al. 2008

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in New Phytologist; Kong et al. 2014 in New Phytologist.

Page 13047, line 24 : This work is very long and impressive, I suggest to insert root slices pictures of the seven species in Supplement.

Response: We supply some slice pictures to show the absorptive and non-absorptive roots. In the supplement pictures, we provide only for *E. chinense* and *C. chinensis*, and slices and details of the anatomical traits for other five species can refer to Long et al. (2013).

Page 13048, line 1 : As the study deals on root order and thin vs. thick roots, it would have been appreciated to briefly describe the determination of absorptive roots.

Response: We have revised this sentence and given the detailed classification of absorptive roots.

Page 13048, lines 4 - 21 : Only two fractions are defined in the Introduction (labile vs. recalcitrant fractions). Could the author unify the terms used in the introduction with the following parts to gain in clarity ?

Response: As pointed out by the reviewer, only two fractions of root carbon was referred to in the introduction while three root carbon fractions were measured in the chemical analyses section. For clarity across the manuscript, we classify extractive as the labile fraction and the other two fractions, the acid-soluble fraction and acid-insoluble fraction, as the recalcitrant fraction. Accordingly, we have added a sentence for such information in the revised version.

Page 13048, lines 10 - 13 : Parenthesis are missing.

Response: The authors appreciate the carefully reminding of this missing. We have added the parentheses in these sentences.

Page 13048, line 17 : Please, could the authors correct the sentence.

Response: As noted by the reviewer, this sentence is not correct and we have revised

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this accordingly.

Page 13048, line 25 and Page 13049, line 21 : It is also very surprising to introduce a new root trait and new set of plant species at the end of this Material & Method section. It would have been appreciated to present the additional plant species in the 'Plant species and sampling site' section.

Response: In this study, we have introduced a new root trait, root EC. We also have given explanations for the using of this trait in our study (see the text for details). We appreciate the reminding of additional plant species in this section. However, we feel it is not proper to put this set of plant species into the "Plant species and sampling site" section. This is because we have not sampled these species in this study. Actually, data of these species were just used for reanalysis to validate our results that were based on only a few plant species.

Page 13049, lines 9 and 23 : The cutting point between the thick and thin absorptive roots should be introduced earlier in the text. This study will gain in clarity by better explaining how thin and thick absorptive root are determined, and by using a common cutting point between the studied plant species and the additional set of 96 plant species. Could the authors explain why the cutting point was not similar between the two set of plant species ?

Response: For the two dataset in this study, the cutoff points are not similar. This may be due to the different frequency distribution of the two dataset. For the current data, root EC followed a normal distribution. While for the 96 species of the previous study, data of root EC followed a skewed normal distribution dominated by thin root species. In this case, the method of using the average of root EC as the cutoff point may cause bias on the grouping of thin and thick roots. Therefore, for the 96 species, we used 182.8  $\mu\text{m}$  root EC as a cutoff to separating thin and thick roots. This cutoff point also corresponded to the functional transition from lower to higher mycorrhizal colonization when increasing root diameter (see Kong et al. 2014; Eissenstat et al. 2015; Liu et al.

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2015). In addition, we acknowledge that there has been no commonly accepted cutoff point to separate the thin from the thick absorptive roots. In this study, the separation of the thin and thick roots is based on statistical distribution as well as root physiology. The methods used here represent one way to discriminate the two root groups. We also expect that more convenient and precise ways can be developed in future studies.

Results section are too concise and would have been easier to understand by presenting first the effects of plant species on the measured root traits before presenting the root strategies and root trait relationships. In addition, it would have been appreciated to see the regression lines on the Figures presenting root traits relationships, and a multivariate analysis to better synthesize the results and to clearly understand the trade-offs between root strategies presented in this study.

Response: We appreciate the comments from the reviewer. Similar to the reviewer, we feel results seem concise. However, they indeed tracked the main findings of our study. We have not adjusted the order in presenting the plant species effects. This is because this section is mainly used to answer for the second hypothesis. Then, we put it after the results answering for the first hypothesis. In the revised version, we have added the regression lines in the figures. We acknowledged that a multivariate analysis may better synthesize the findings of this study. However, the multivariate analyses are often based on linear relationships. This may not be suitable for the traits of chemical fractions that are usually non-linearly related to root tissue density. In this study, we used the bivariate regressions. Although these relationships seem too many, they did give supports of our new view on root economics spectrum from different aspects plant functional traits. Anyways, we appreciate the valuable suggestion of multivariate method.

Page 13050, lines 14 and 19 : What does 'medium', 'higher' and 'lower' mean ? Please, could the authors specify the thresholds used ?

Response: The "lower", "medium" and "higher" referred to root tissue density. These

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are used to indicate the relative size of root tissue density. Here, we did not aim to clearly present the definition of "lower", "medium" and "higher" root tissue density. These terms were used just to discuss the general patterns of chemicals with root tissue density. This can be seen in the discussion section (Page 13052, lines 15-21).

Supplement, line 20 : It is very surprising to modify the dataset. Please, could the author explain why they removed some points to arrange the results ?

Response: We appreciate the reviewer for this comment. Two data points removed in the analysis of thick absorptive roots for the 96 species study. This is because root tissue density-root N concentration relationship in these thick roots was greatly influenced by these two data points. For example, the above relationship was significant ( $R^2=0.24$ ,  $P=0.01$ ) when including these two data points, but not significant ( $R^2=0.025$ ,  $P=0.45$ ) when excluding the two data points. Therefore, the two data points were outliers, and thus were removed from the analysis of the thick roots.

Discussion : Conclusions of this study seem to be highly influenced by the methods used to separate thin and thick roots, and the definition of C and N fractions as well, which imply to better define these traits in the 'Introduction' and 'Material and Methods' sections.

Response: As in the revised "statistical analyses" section, we presented details on separating the thin and thick absorptive roots. Although there are no commonly accepted criteria for classifying the thin and thick absorptive roots, we feel that our method to separate these roots may not greatly influence the conclusion of this study. This is because reanalyses of the previous 96 species also demonstrate different trait relationships between the two root groups. Therefore, our conclusion, despite based on a few species, may not be a coincidence but a common rule. Moreover, it has been revealed recently that the thin and thick absorptive roots do follow different nutrient foraging strategies: the thin ones depend mainly on roots themselves whereas the thick ones depend on mycorrhizal fungi (see Eissenstat et al. 2015 in *New Phytologist*;

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Liu et al. 2015 in *New Phytologist*). One speculation from our study is that with efficient partner of mycorrhizal fungi, thick absorptive roots may follow a different resource acquisition-conservation pattern. As such, we propose in the revised manuscript that future studies may stress on mycorrhizal fungi (i.e., the composition and function) in thick absorptive roots.

Page 13050, lines 20 - 27 : Discussion of the root traits relationships should be better supported by showing the regression lines, which are not obvious to see on the presented figures.

Response: We have added the regression line for these figures.

We have uploaded the revised manuscript as well as supporting information (both with and without tracked revision change) in the supplement zip file.

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/12/C7012/2015/bgd-12-C7012-2015-supplement.zip>

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