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Interactive comment on “Soil carbon sequestration by three perennial legume pastures is greater in deeper soil layers than in the surface soil” by X.-K. Guan et al.

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Responses to the Reviewer

General comments The study under review aimed to assess the contribution of three perennial legume pastures grown on a degraded land for 7 years to soil C sequestration. While it is widely known that growing a perennial vegetation cover on a degraded land leads to higher soil C concentrations and stocks, the novel finding of this study is that this increase is higher in subsoil layers than the surface layer. However, at the same time, there is no explanation as to why there are more stocks in subsoil layers than the surface layer since the latter is home to most of the plant root biomass hence

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higher C inputs especially under pastures. RESPONSE: Thank you for indicating that the paper needs to be revised. We have endeavored to revise the manuscript as suggested below.

Specific comments The discussion section needs substantial improvement since in its present form, it looks like an extension of Results'. For example, the authors can compare the rates of soil C accumulation in their study with those of similar studies. Above all, they should find an explanation as to why there is more soil C accumulation in deep soil layers and how it is possible that plant species producing substantially varying amounts of biomass end in sequestering similar amounts of soil C under them. Unfortunately, the authors apparently did not estimate the amount of root biomass present in different soil layers that would have been helpful in explaining the results. However they can speculate based on other related studies. RESPONSE: Thank you for the suggestion. We agree and have completely rewritten the Discussion. See lines 216-225, line 231-253, line 265-271 and line 285-292.

Technical comments Page No. 10116 Lines 5-10: “and to estimate the long term potential for SOC sequestration in the soil under the three forage legumes” must be deleted. This gives the impression as if the authors intend to make future projections which they do not. Similar statements elsewhere in the manuscript like in the discussion section should be removed. RESPONSE: Thank you for indicating that. The sentence has been deleted. See lines 25-28.

Line 14: “in the bare soil” instead of “under bare soils” RESPONSE: Thank you. It has been changed to “in the bare soil”. See line 33-34.

Lines 15-16: Change the sentence to “The sequestration of SOC in the 1-2 m depth of the soil accounted for 79, 68 and 74 % of the SOC sequestered in the 2m deep soil profile under alfalfa, bush clover and milk vetch, respectively. RESPONSE: Thank you. The sentence has been changed. See lines 34-36.

Lines 22-24: Isn't it other way around i.e. soil C stocks are two times of those in

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terrestrial biomass and three times of those in atmosphere? RESPONSE: Thank you. The sentence has been changed to “Excluding carbonated rocks, soils constitute the largest surface carbon pool, approximately 1500 Gt, equivalent to almost twice that in the terrestrial biomass and three times that in the atmosphere”. See lines 43-45.

Page 10117 Lines6-8: over what time span this depletion has occurred? RESPONSE: The data was calculated from Wu et al. (2003). The time span was not mentioned. Now, the phrase has been changed to “Globally, 24% of the SOC stock has been lost through the conversion of forest to cropland (Murty et al., 2002) and 59% through the conversion of pasture to cropland (Guo and Gifford, 2002).” See lines 50-52.

Page 10118 Lines 10-13: I don't see any difference in the two stated objectives. RESPONSE: Thank you. The objective of this manuscript has been shortened to “assess the effect of alfalfa and two locally-adapted forage legumes, bush clover and milk vetch, on the SOC concentration and SOC stocks accumulated annually for 7 years over a 2-m soil profile”. See lines 83-85.

Line 24: ‘The site is level’ means “The site is plain”? RESPONSE: No the site was level, i.e., it was not sloping. The sentence has been changed to: “The level site is located at 1220 m above sea level.” See line 96.

Page 10119 Line 7: Fertilizer application rates mean 108 kg N/ha? RESPONSE: Thank you. The units have been corrected. See line 105.

Line 8: change “the site remained fallow” from ‘the site lay fallow’. RESPONSE: Thank you. The phrase has been changed to “the site remained fallow”. See line 106-107.

Lines 24-25: Change the last sentence to “Treatments were completely randomized in three replicate blocks”. RESPONSE: Thank you. The sentence has been changed. See line 123-124.

Page 10121 Line 2: replace ‘by Statistical’ by ‘using Statistical’. RESPONSE: Thank you. The word has been changed. See line 152.

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Page 10123 Lines 22-26: Root biomass does influence the rate of C deposition thereby its sequestration in soil. But the qualitative differences between different roots may influence C deposition significantly e.g. if a plant produces more fine root biomass than the other, even if producing lower overall biomass, it is likely to have higher root turnover rate in the soil that may lead to higher soil C accumulation. See studies on fine root biomass turnover and C stabilization. Similarly higher fine root biomass versus coarse root biomass is likely an indication of higher exudation rates which influence the stability of plant C in soil. See Shahzad et al. 2015 SBB. RESPONSE: Thank you for this comment. As indicated above the Discussion has been completely rewritten, the reference included and the fine root turnover now discussed. See lines 216-225, line 231-253, line 265-271 and line 285-292.

Page 10124 Lines 25-29: It is true that most soil C is derived from root C but that doesn't explain the difference of plant C sequestration in different layers in this study. Being the semi-arid nature of the area under study, plants must have produced deep roots and of varying specific root lengths depending on the plant type. The presence of different biomass/specific-root-length along the profile might have resulted in varying sequestration of varying C amounts along the profile under different species. However this remains a speculation until one knows the root characteristics. RESPONSE: Thank you for this suggestion. As indicated above the Discussion has been completely rewritten and the points that you raise are now discussed. See lines 216-225, line 231-253, line 265-271 and line 285-292.

Page 10125 Lines 3-5: Just a question out of curiosity: why did the authors chose to study only the legumes which are high water consuming plants in a semi-arid area? RESPONSE: Alfalfa has been grown on the Loess Plateau of China for many decades. It is highly productive and provides incomes for farming households. Over the last few decades, alfalfa has been shown to be an important tool in controlling soil and water erosion, but questions are now being asked in semiarid areas about its depletion of deep soil water and the effect on subsequent cropping. However, studies from Institute

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of Soil and Water Conservation, Chinese Academy of Sciences, have shown that soil water in the upper 1 m is recharged in a wet year and it can be rewetting in 5-6 years. In order to eliminate these doubts about alfalfa, other legumes have also been planted on the Loess Plateau of China. The productivity of milk vetch was similar to alfalfa in its early growth stages, bush clover was more resistant to drought stress, while both used less water than alfalfa, giving these two legumes advantages over alfalfa in arid and semiarid regions.

The new version of changed manuscript has been uploaded in PDF format as supplement file.

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/12/C6137/2015/bgd-12-C6137-2015-supplement.pdf>

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