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# *Interactive comment on* "Refining physical aspects of soil quality and soil health when exploring the effects of soil degradation and climate change on biomass production: an Italian case study" *by* Antonello Bonfante et al.

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We thank the reviewers dr.Schmidt and his students for their comments. The procedure being followed in preparing this review is innovative and quite interesting. We will tailor our detailed reaction to the composition of this particular review panel. We appreciate the comment that consideration of phenoforms and the IPCC scenario's to express effects of climate change are supported by the reviewers. The first part of their comment suggests that the key message of the paper has apparently not been effectively communicated by us and we will pay particular attention in our revision to address this issue. As indicated in the paper, both the soil quality and soil health definitions refer to “soil functioning”. That’s why we focus on defined soil functions, and particularly on function 1: biomass production ( which is also a ecosystem service, not only defined by soil scientists but with input from additional disciplines). That value for biomass production (Ya) can either be measured or estimated by simulation, we have done the latter in this exploratory paper. We are concerned about the statement in the cited recent Cornell bulletin that their procedure is only valid for the NorthWestern USA. The prospect of having many different local systems in future defining soil quality and soil health is not good because lack of a widely accepted general system to define soil quality and health (which we don’t have as yet in contrast to water and air quality) forms an increasingly serious barrier to communicate well with citizens, stakeholders and policy makers. We therefore use the worldwide applicable term Yp (potential production), that expresses a yield assuming that water and nutrient supply are optimal and that pests and deseases don’t occur. Every soil at any particular location has a characteristic science-based Yp value (for a representative crop at that location). Next we have Yw, which includes the above assumptions, except that it is determined by local water availability and that’s why it is usually lower than Yp. When interpreting soil maps, we have to define a “representative”profile for which calculations are made. We introduced the phenoform concept because soil processes are quite different as a function of different forms of management. In our exploratory analysis we assume the presence of a plowpan, surface flow when rainfall exceeds in the infiltrative capacity of the soil and erosion ( assuming that erosion does not change the genoform classification, because our paper is focused on the behavior of individual soil types with a given classification!). In line with Yp, Yw assumes that nutrient supply is optimal and that pests and deseases don’t occur. Yw does, therefore, not only address soil physical aspects but also (implicitly) other aspects that affect biomass production. We arbitrarily distinguished three phenoforms, but others can be defined as well, ideally on the basis of field research. Variation of the organic matter content (%C) as a function of soil management is an obvious possibility and provides a link to soil biology as %C can be seen as a proxy value (we refer to Bouma and Wosten, 2016, and references therein, where a range of %C values is presented for Dutch clay soils) We suggest that soil quality can be represented by a characteristic range of Yw values for any particular type of soil , expressing properties of a series of phenoforms. Actual soil health, based on measured or simulated Ya values, will then have a position within this range. If the distance with Yw is small, health is relatively good and it gets worse as the distance increases. The ratio Ya/Yw x100 provides a soil-specific number which is not only good for communication purposes but also indicates where gains can be achieved (see figure 7). What we have not covered in our paper is what happens next. Your questions refer to that and we will address this in the revised paper. The reason that actual Ya (soil health) has a certain distance to Yw can have many reasons (see the definition of Yw): not only shortage of water but also lack of nutrients or occurrence of pests and diseases. These reasons have to be investigated and corrective measures devised. We focus on Yw and not on Yp because water regimes are relatively difficult to change in contrast to fertility and ocurrence of pests and deseases for which rapid management measures are available (YW can be considered the environmental yield potentiality (soil phenoform + climate) of a specific site). The %C is a proxy for soil biology and different forms of management can increase %C but this may take decades. In this study we have not defined Phenoforms based on different %C of surface soil. In the Cornell protocol, physical, chemical and biological soil quality and health are considered seperately: three numbers are obtained and mutiplied. We suggest that the three processes are highly interrelated and we propose a logical sequence, as mentioned above: start with moisture regimes defining Yw, then analyse why Yw is different from Yp and suggest appropriate management in terms of irrigation or drainage, fertilization practices and application of pest and desease measures. Soil biology can be very dynamic in time and space and it is a function of local hydraulic, physical and chemical soil conditions and %C can act as a proxy for soil quality and health (see soil functions 3 and 6). A proposed management measure can be focused on an increase of %C if this is low in the soil being characterized. . The reviewers present a valuable comment in that we indeed assume that soil properties don't change as a result of climate change. We will now state so explicitly. Soil forming factors take thousands of years so this seems realistic. We focus on what the effects of compaction etc. may be following climate change. We will remove conclusion 5 . Good point. We have checked the number of repetitions in the Materials and Methods section. We don't believe that sections 2.2.and 2.3 overlap too much. From previous work we have learned that readers are critical about modeling: they want to see all the details. Now we discuss first on modeling in general and next on the details of the model. This seems logical. Detailed comments: Abbreviations will be checked; a reference will be provided with more info on the soil series ( lines l9/92). But Table 1 provides all the necessary data, doesn' t it? Indeed, Yw can be equal to Yp, but this is unusual. A good point is raised about Ya/Yw x100 values in future. Obviously we cannot, in contrast to the present, not measure Ya values in future. But we can simulate them. In fact this is a major advantage of using simulation of crop growth. (line 210). We have added a sentence. LAI evolution refers to the developemtn of the Leaf Area Index, needed for simulation ( line 226). The soil-water-atmosphere-plant model cannot directly be used to define chemical and biological properties. As explained above, by defining Yw it can help to focus chemical and biological soil management, based on the gap between Yp and Yw. And, finally, this study does not necessarily imly that procedures followed are the only way to assess effects of climate change (line 400). Let many flowers bloom!

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Discussion paper