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Interactive comment on "Greenhouse gas balance of cropland conversion to bioenergy poplar short rotation coppice" *by* S. Sabbatini et al.

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We thank both the reviewers for their comments and suggestions that helped us to improve the quality of the manuscript and to make it more readable and understandable. Here below we report the answers ('A:') to the reviewers' comments ('R:') and what we implemented in the manuscript.

Reviewer: 1

R: General remarks: Sabbatini and colleagues present a greenhouse gas balance of a Mediterranean site planted with bioenergy poplar short rotation coppice (SRC) measured over two years and compare results to a reference site under agricultural use. They conclude that the reference site is a small greenhouse gas (GHG) source, while

the poplar short rotation coppice is a considerable GHG sink of 2.2 kg CO2 eq m-2 over the two years of investigation taking into account CO2, CH4, and N2O fluxes, management activities, soil organic carbon losses, GHG offset in terms of natural gas savings in the process of heat production, and biomass exports with regard to reemissions as CO2 after burning. The topic is within the scope of the journal and of high environmental and political relevance as the production of bioenergy in Europe is a possible strategy to reduce GHG emissions. General design and approach are valid and mostly well presented; methods are thoroughly described. However, the current version of the manuscript has quite a number of shortcomings – most of them are minor – so that revisions are needed in order to bring it into an acceptable form. If the below-mentioned points are considered – mainly by putting some clarifications into the text – I feel that this will be a nice and much appreciated contribution to the scientific community.

A: We thank the reviewer for considering our paper and for her/his interesting suggestions. We tried to implement as much as possible the suggested changes.

R: Major points: - This paper offers comprehensive details at some points, but lacks transparency at others. For example, the presented GHG budget is based on two years of measurements, i.e. one poplar rotation. It should be clearly pointed out in the Abstract and Discussion that this budget does not represent the period right after conversion from arable land to poplar coppice as one would expect much higher GHG release from the ecosystem to the atmosphere immediately after conversion. This fact needs to be discussed in the right context and conclusions should be verified with regard to a possibly changing budget of the newly established SRC site over time.

A: We agree that the period of calculation of the GHG budget has to be clear from the beginning, and we put in higher evidence than before the indication that the GHG budget was not calculated right after the conversion of the arable land, but starting from two years later. To include the expected large emissions following the arable land conversion in the calculation of the GHG budget, a linear regression between the SOC content of the studied SRC and an older SRC located close-by was built. The expected

value at the beginning of the cultivation was then extrapolated from the regression, and compared with the one of the REF site: the difference between them was attributed to the SOC loss at the conversion. CH4 and N2O emissions at the installation were considered negligible on the basis of the low fluxes measured both in the REF site and the lab experiment. A paragraph was inserted in the discussion section.

R: - CO2 fluxes are identified to be the major contributor to the full budget. However, their presentation is poor. Please provide an additional figure showing the seasonal development of CO2 exchange so that the reader gets an idea of possible controlling factors and an illustration of periods when discrepancies occur between sites and years.

A: We thank the reviewer for his suggestion. Even if we did not include a detailed ecological analysis of the FCO2 to avoid lengthening the manuscript, however we agree that it is worth it to show the seasonal trends of the most important flux contributing to the GHG budget. We added a figure to this end and the trends of the two most important drivers (air temperature and soil water content), briefly discussing the inter-annual variability and the differences between sites.

R: - Discussion is missing on sustainability of the presented conversion method, particularly on field operations such as irrigation. With regard to the GHG balance, this strategy seems to work out quite well, but what about other parts of the environment, e.g. the local water balance, etc.? Please add some thoughts on that.

A: In order to improve the readability of the manuscript and avoid possible confusion in the reader, we decided to focus the evaluation of the suitability of the LUC on the calculation of GHG budget, leaving outside other environmental factors. We agree that a comprehensive environmental LUC suitability would include the analysis of impacts on local water balance, nitrates leakage, VOCs, etc., though the discussion of these points was beyond our scopes. That said, we agree that the points should be cited and we added some considerations on irrigation-related aspects because of their relevance

for poplar cultivations in Mediterranean areas.

R: - Manual chamber measurements: Using just three samples to calculate one flux rate is a bit dangerous. A huge additional uncertainty is induced. I know how challenging these measurements are and I appreciate their consideration in this study, but proper error estimations should be provided (see specific points).

A: We are aware that 3 is the minimum number of samples required for flux calculation, and that increasing this number might result in a more accurate calculation of fluxes. However, as the reviewer correctly underlines, manual chambers entail a huge amount of work. For that reason in order to have a higher number of samples we would have needed to reduce the number of collars in the sites. Instead we preferred to have 9 sampling points in each site, which was crucial especially in the SRC where we wanted to account for all the three different conditions (line, irrigated and non-irrigated interlines), sampled 3 times each. 3 samplings in time, frequently used in studies performing manual chamber measurements (e.g. von Arnold et al., 2005), have been chosen as an acceptable trade-off between excessive labour and uncertainty in flux calculations. The error we observed was variable and the magnitude of the fluxes low. For that reason we expect that even adding 1 point (so 4 rather than 3 points to the fit) would not dramatically improve the results, as a slight variation in the slope would not induce significant changes in the overall picture we have defined. Hence the uncertainty estimation, based on the standard deviation of the different collars and thus representing the spatial variability, provides in our opinion more relevant info for the GHG budget. This fact has been highlighted in the discussion of the low non-CO2 emissions from soil.

R: - I'm a bit skeptical whether (such) a (comprehensive) presentation of the soil incubation studies is needed. Do they add any valuable insights with regard to the main aim, i.e. the GHG budget, of the paper?

A: We think that the laboratory studies help to understand the field dynamics. Despite

our effort, we are aware that manual sampling might not cover the whole temporal variability occurring in the field, in particular we could miss peaks of emissions, thus introducing some subjectivity. In this specific case we wanted to be sure that the low emission values, in particular of N2O, were due to specific field factors, e.g. the lack of occurrence of combined conditions which can trigger high N fluxes (i.e., high water content and high N availability) or biological specific limitations, e.g. slow microbial processes due to soil conditions as found in other sites. Laboratory data brought more evidence to discuss these topics on the basis of scientific evidence rather than pure hypotheses. We better clarified the need for this lab experiment in the manuscript.

R: - All in all, the paper reads well and I like it. Nevertheless, please avoid these terribly long sentences. Also, check for correct grammar (prepositions, etc.). It doesn't sound quite right at some points in the text. I guess it'll be quickly and easily fixed. There is not so much to change, but it will greatly improve readability and overall quality of the paper.

A: We tried to improve English grammar and clarify some parts of the text. However we are aware that the BG charges include an English copy-editing service for final revised papers (http://publications.copernicus.org/services/copy_editing_for_english.html)

R: Specific comments and technical corrections required:

A: All the specific comments and technical corrections required were implemented in the test.

Exceptions:

R: - P.8039, l.24: Remove part in brackets. SRC has been defined earlier.

A: SRC has been defined earlier, here we define the name of the sites, e.g. "SRC site".

R: - P.8040, l.10: Did you consider the possible role of nitrogen compounds in your estimation? Ammonia and aerosol NH4NO3 do also influence the GHG budget at local scale. Also, by substantially modifying the surface resistance through growing

poplar trees, an increase in nitrogen deposition can be expected. However, it's tricky to include these aspects into CO2 equivalents due to their reactivity, uncertain emission factors, etc. I'm not asking for an extra term in Equation (1), but since a GHG balance is investigated, the nitrogen part should be kept in mind and should at least be mentioned at some point in the paper.

A: The role of nitrogen compounds in this study was attributed to the emissions from soil as N2O (FN2O), and to the energetic costs due to the production of fertilisers (in FMAN). Other possible contributions to the balance (e.g. aerosol NH4NO3, N deposition and leaching) were considered minor and not included in the GHG budget. This fact was highlighted in the discussion section. We stress here however that Schmidt-Walter and Lamersdorf, 2012 found that nitrate leaching from SRC cultivation is small once the SRC is established, compared with arable rotations, and that the possible higher nitrate losses at the installation would be likely compensated by lower losses in the productive system in respect to croplands. Hence, speculating an analogy with this analysis for our study, this result would strengthen the advantage of the GHG budget of the SRC site in respect to the REF site.

R: - P.8046, l.13-14: This means that only three samples were used to calculate one flux, right? In my opinion four samples are required to derive a somewhat robust flux estimate. A huge error is additionally induced, let alone the uncertainty of vial sampling with subsequent GC analysis itself. This needs to be discussed and the respective error estimates need to be included in the final numbers.

A: See answer above

R: Figure 3: Why only 14 months of measurements at REF site?

A: We began manual chambers measurements in the REF site at the beginning of April 2012 due to a technical problem: this fact has been clarified in the text. This means that the first months of cultivation for the REF site were not covered by non-CO2 soil measurements. However as this period was in wintertime we did not expect substantial

differences with the rest of the time, and thus we considered zero emissions from this period in the calculation of the GHG budget.

Reviewer: 2

R: I have read with great interest the manuscript and my final recommendation is that it could be published in this Journal after minor revision. The subject of the paper, in fact, addresses relevant scientific questions within the scope of the Journal and it can me seen as a possible strategy to reduce greenhouse gas emissions. The paper refers to a real case-study in a Mediterranean site, in Italy, where a greenhouse gas balance of two different agricultural land, planted with Poplar SRC and grassland-wheat rotation, has been made over a period of two years to evaluate the feasibility of the land use change to reduce GHG emissions. By taking into account all emissions coming from all crops management activities, results show that Poplar SRC represents a GHG sink by having -2202 gCO2eqm-2 compared with 156gCO2eq m-2 of the grassland-wheat rotation crop. This allow authors to conclude that the experiment led to a reduction of GHG concentration in the atmosphere, that is Poplar SRC for energy purpose is a suitable crop for the climate mitigation. In general the manuscript is well structured and clear: title reflects the content of the paper and the scientific methods are valid and clearly described. Assumptions are also well outlined as well as the credit to other works already present in literature. Moreover, authors describe the experiment in detail and results are quite sufficient to support the conclusion.

A: We thank the reviewer for appreciating our work and for useful comments on it, which we think helped us to make the paper more clear

R: Authors, in fact, refer only to one cycle of the short rotation coppice (i.e., two years) and not to the whole crop cycle that usually is 12 years. I suggest underlining this aspect both in the abstract and in the text.

A: We better clarified in the text the information concerning the period considered in the GHG budget calculation

R: Concerning the discussion of results, I suggest to divide section 4 (Discussion and Conclusion) into two parts, that are Discussion and Conclusion, respectively.

A: We agree and split the section in two parts

R: This is because the manuscript not only could appear more clear but also because Discussion need to be extended by considering all the aspects of the crops management related to all impacts to the environment (air, soil, water), both for Poplar and grassland-wheat.

A: We thank the reviewer for her/his suggestion. The objective of our work and of the present manuscript was to test the suitability of a LUC towards SRC from a GHG perspective. We are aware that an overall environmental assessment would have contemplated the inclusion of several other factors, but we decided to focus only in the GHG budget, otherwise the paper would become too complex and long. However, due to the specific climate condition (Mediterranean) where the SRC is cultivated, we added some thought related to irrigation, and thus to the expected impact of the LUC into the water balance.

R: Concerning English language, a revision is suggested.

A: We tried to improve English grammar and clarify some parts of the text. However we are aware that the BG charges include an English copy-editing service for final revised papers (http://publications.copernicus.org/services/copy_editing_for_english.html)

R: Moreover, check the use of parenthesis when data are presented and when references are reported. Sometimes they seem to be in a wrong place in the text, as for example line 15 in the abstract or pag. 8039 line 9-10.

A: We are grateful for the suggestion. The indicated unclear parts of the test have been clarified

R: Table 3 is not clear: does Tractor1+2 mean the total diesel consumption of these tractors together or it is the same for each tractor? Please refer to tractors also in the

site description when you describe the operations and then also in section 2.6.

A: We thank the reviewer for his comment. We clarified this point both in the test and in the Table

References

Schmidt-Walter, P., & Lamersdorf, N.P. (2012). Biomass production with willow and poplar short rotation coppices on sensitive areasâĂŤthe impact on nitrate leaching and groundwater recharge in a drinking water catchment near Hanover, Germany. BioEnergy Research, 5(3), 546-562.

von Arnold, K., Nilsson, M., Hånell, B., Weslien, P., & Klemedtsson, L. (2005). Fluxes of CO2, CH4 and N2O from drained organic soils in deciduous forests. Soil Biology and Biochemistry, 37(6), 1059-1071.

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