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Low-ILUC biofuel production in marginal areas: can existing EU Policies support biochar deployment in EU MED arid lands under desertification?

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Arid lands in EU MED areas are increasing in extension year by year, as it is well documented by many studies of International Institutions (as EC-JRC, EEA, etc). EU MED farmers face the dramatic effects of extended drought conditions, that combined with extreme phenomena as floodings or thunderstorms make economic profitability of agriculture very low or even negative. This is associated with a clearly increasing abandonment rate of agricultural land in EU. The most EU critical areas are located in Spain, but also Greece, Italy and Portugal, as well as in the non-EU Southern rim of the MED basin. Biochar could represent an effective approach to fight desertification, together with other agronomic practices which can vary depending on the specific location or crops. Biochar can be cheaply produced from residual biomass through processes such as slow pyrolysis or hydrothermal carbonization, and its combination with compost obtained from the Organic Fraction of Municipal Solid Waste (OFMSW) or digestate from anaerobic digestion can offer both a short and a medium-to-long term effect in dryland agriculture. These lands, that otherwise would inevitably leave the active utilisation in conventional agriculture, would be suitable for energy crop cultivation, as drought resistant oil crop, well meeting the latest indications in the EC REDII proposal.

Through biochar (and derived product) application, the loss of Utilised Agricultural Land in EU MED drylands can be prevented. From the policy side, it thus makes sense to investigate if existing policies are sufficient to facilitate the wide market deployment of biochar, or if new instruments are needed. Our analysis demonstrates that currently operational EU policies, could be well used to implement biochar related actions in arid lands. However, most often these measures are not transferred into concrete programmes at regional level, especially in the agricultural sector. In fact, EU and Member States already have quite a large number of instruments that can directly or indirectly support actions targeted to increase the resilience of these arid lands to Climate Change, generating a significant impact on the environmental and socio-economic situation. Policy should support initiatives that can provide clear evidences, be cost- and environmentally-effective, and adapted to local conditions. The present work investigated EU/MS policies that could potentially support the improvement of soil resilience to climate change in EU MED region, by enabling widespread diffusion of biochar.

The EU legislative elements that were considered are the EU agricultural policy, the EU Carbon sequestration & storage policy (seen in the framework of the COP21 agreement and its core goals), and the EU renewable energy policy, even if others would also apply. We considered sunflower cultivation in dry land of Central area (Tuscany) of Italy. Results showed that marginal land could be seen as an opportunity to produce low-ILUC biofuels (as mentioned in the EC REDII proposed Directive), without conflicting with food production or generating negative effects on GHG emissions. The Long-term storage of C in the soil through biochar would perfectly match with the Climate strategy defined at International level (Paris COP21 and following). Soil, after ocean, is the second most abundant C sink: Paris-COP21 called for C-negative actions (and not just C-neutral ones). In this respect, the proposed approach would perfectly match with EU (ETS) and International (COP21) policy for the coming decades.

1. Introduction

Lignocellulosic biomass that has been carbonized through slow pyrolysis or hydrothermal carbonisation is today identified with the term “biochar” (Brown et al, 2011; Lehmann et al, 2009). Recently, also the solid product from biomass gasification is included in the “biochar family”. However, the chemical and physical characteristics of these three solid products, as well as the level of contaminants, considerably differ, depending on the specific process and technological solution adopted. Biochar and its derived products (through chemical or biotech-based upgrading) can be used as soil amendment. Biochar is mainly composed by stable carbon, which can resist to microbial and chemical attack: thus, biochar offers a large potential for C sequestration on a long-term basis, and provide long-term storage of carbon in the soil. For this reason, biochar is seen as a major strategy to store C and mitigate climate change effects (Griscom et al, 2017). Biochar, in addition to the use in agriculture, can be employed in a vast number of other uses, from flue gas/liquid stream cleaning (activated charcoal), to steel making (metallurgical charcoal), silicon making. In this work we will concentrate on the agricultural use of biochar and COMBI (the combination of biochar and compost) in agriculture, a field of research that is receiving great attention worldwide recently. Biochar use in agriculture can:

-Increase moisture retention capacity of difficult dry soil, while also restructuring the soil matrix
-Create a porous suitable environment for microbial
-Regulate soil pH
-Sequester and slowly release main nutrients (as nitrogen), favouring crop growth, reducing N-leaching and N_2O emissions
-Store stable carbon in the soil

Biochar – if properly used in the right soil type and climate - attracted the interest of farmers as it can potentially increase crop yields, in a virtuous combination with an improved sustainability of farming. Nevertheless, the effect of biochar and derived products in agriculture depends on the biochar characteristics, the crop and soil characteristics, the volume of biochar deployed on land, the local climate, and other elements, thus making the actual impact very biochar-type and site specific. The addition of biochar, a very porous material (typically in the range of at least some hundreds g m^{-2} (Suliman et al, 2017), to the soil improves the water retention capacity, one of the key elements for crop growth, which is also function of pore dimensions and char surface characteristics. This property of biochar makes it very interesting arid regions, including EU MED, favouring agriculture in marginal land while preserving soil organic carbon and sequestering stable carbon in the soil. Since decades this area is subject to progressive and continuous desertification due to climate change effect, as largely documented by – among many others - the studies of the European Environment Agency on the MED basin, and EC JRC in its World Atlas of Desertification (EEA, 2017; EC JRC, 2017). The combination of biochar with compost from the Organic Fraction of Municipal Solid Waste or composted digestate from Anaerobic Digestion can create synergistic effects, with short (from compost) and long-term (from biochar) benefits to agriculture (Godlewska et al, 2017).The combined use of biochar and compost to improve soil resistance under dry conditions could be a feasible approach to fight land abandonment due to desertification in the EU MED area: however, proper support measures are necessary for wide deployment of biochar in agriculture. The scope of our work is to address the EU policies and model the possible effects of supporting measure in the cultivation of sunflower in central Italy (Tuscany).

2. Methodology

The analysis considered the EU Common Agricultural Policy (CAP) as the main instrument to promote biochar use in EU arid regions, combining this with the Energy and Climate policies, and investigating if existing EU measures could support the biochar chain, or if otherwise new policies are needed. It is worth to mention that the EU Circular Economy package could also very well fit to the scope, even if it was not considered in the present work. A cost model for Sunflower cultivation in Tuscany has then been developed and used for the study. Data for sunflower yields and crop production costs were derived from actual on-field experience of the University of Florence in Tuscany. Both conventional and high-oleic sunflower under three different cultivation regimes were considered, and the extreme (min and max) values for the following parameters sued:

• Representative average yield per ha for conventional, minimum tillage and no tillage cultivation;
• Representative total costs per ha for conventional, minimum tillage and no-tillage sunflower;
• Minimum and maximum seed selling price for both conventional and high-oleic sunflower.

Based on that, and considering the average CAP support to sunflower cultivation in Italy, the range of gross farmers’ income in case of conventional agriculture in conventional land was calculated, and results taken as reference case.

Reasonable crop yield increase curves versus cultivation in marginal land were then modelled, differentiating between the case of biochar only or COMBI addition (the amount of biochar varying accordingly). From a policy point of view, we assumed to cover the additional biochar/COMBI deployment costs with CAP measures in the range of 110-200 € ha^{-1} y^{-1} over a period of 5 years (compared to the effect of C storage lasting at least a century). This C-sequestration environmental action is also in full line with the indications of Paris COP21 and following COPs. The EU Renewable Energy policy, namely the biofuel policy in RED/REDII, was considered to provide a premium for oil crops cultivated in this marginal land. The same support as proposed by the EC in its first REDII draft for aviation biofuel (European Commission, 2016), i.e. a 1.2 (or 120%) multiple counting on the vegetable oil, was considered. This support was weighted on the typical oil content of sunflower seed (~40% w/w): 120% premium on oil content is thus equal to an average of ~108% on seed. Farmers' returns were then calculated again, and compared to conventional and marginal land sunflower cultivation.

3. Results

Regarding the Utilised Agricultural Area (UAA) in the EU MED, EUROSTAT and FAOSTAT provide similar but different set of data. These have then been compared for three reference Countries. Even if differences exist, the trend over the time (e.g. decades) was the same, and the absolute differences within an acceptable range. FAOSTAT was then adopted as reference source for the following analysis.

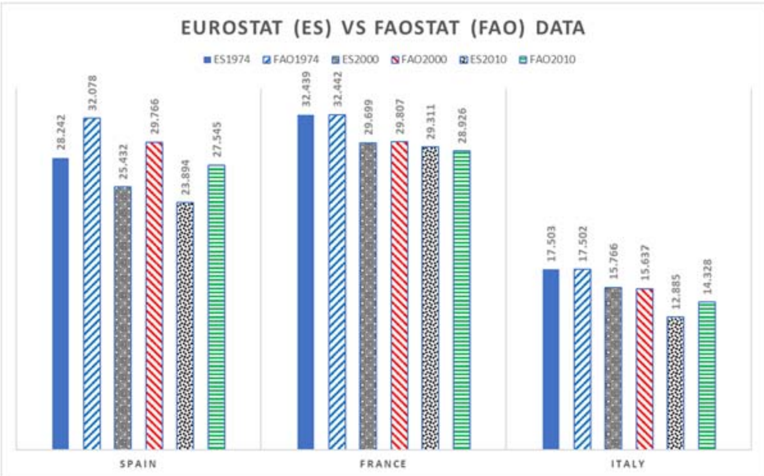

Figure 1: Comparison between Eurostat and FAOSTAT data on land use in three representative EU MED Countries.

As reported in the following Fig 2 and 3, almost all EU MED Countries showed a considerable reduction in UAA. Overall, more than 12 Mha and 18 Mha were lost from the EU MED agriculture in the period 2015-1992 and 2015-1970 respectively, i.e. 120.000,00 km^2 and 180.000,00 km^2. 180.000,00 km^2 means almost 6 times the area of Belgium or 4 times Switzerland, 60% of the Italian, 50% of the German or 25% of the French land.

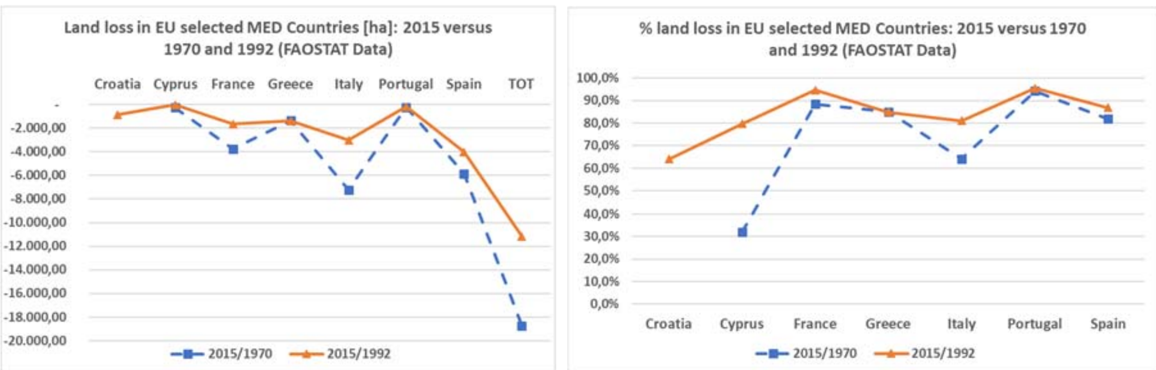

Figure 2: Reduction of Utilised Agricultural Area (UUA) in EU MED countries. UUA loss ([ha], left), UUA remained in the selected time interval (%, right)

In the following figures the farmers' gross returns are given as calculated based on assumptions reported in the previous section. Even conventional land and farming can determine very low return if seed yields decrease below a certain level. Marginal land is almost always uneconomic, while biochar addition only provides minimum benefit (even if in the best case positive) compared to COMBI addition.

Case 3 below corresponds to a support of 200 € ha^{-1} y^{-1} over a period of 5 years for Biochar (Fig 3) and 110 €/ha to over the same period for COMBI. Case 4 considers an additional premium of 108% on seed value (120% multiple counting on produced vegetable oil). Case 1 and 2 instead assume no support to the farmers for sunflower cultivation.

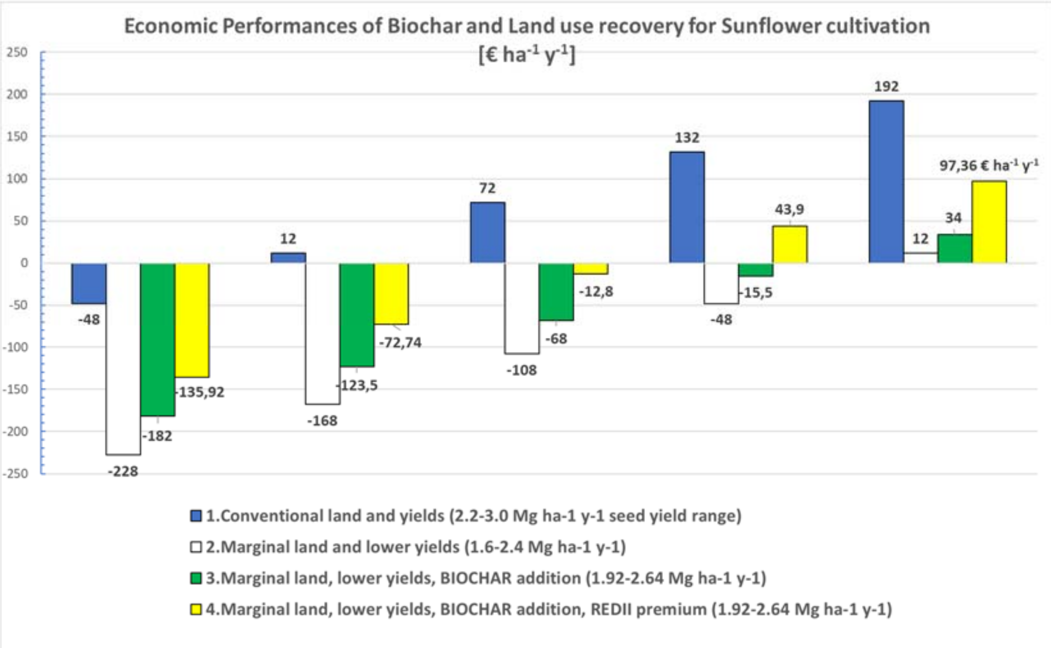

Figure 3: Estimated gross farm income with biochar and various policy support

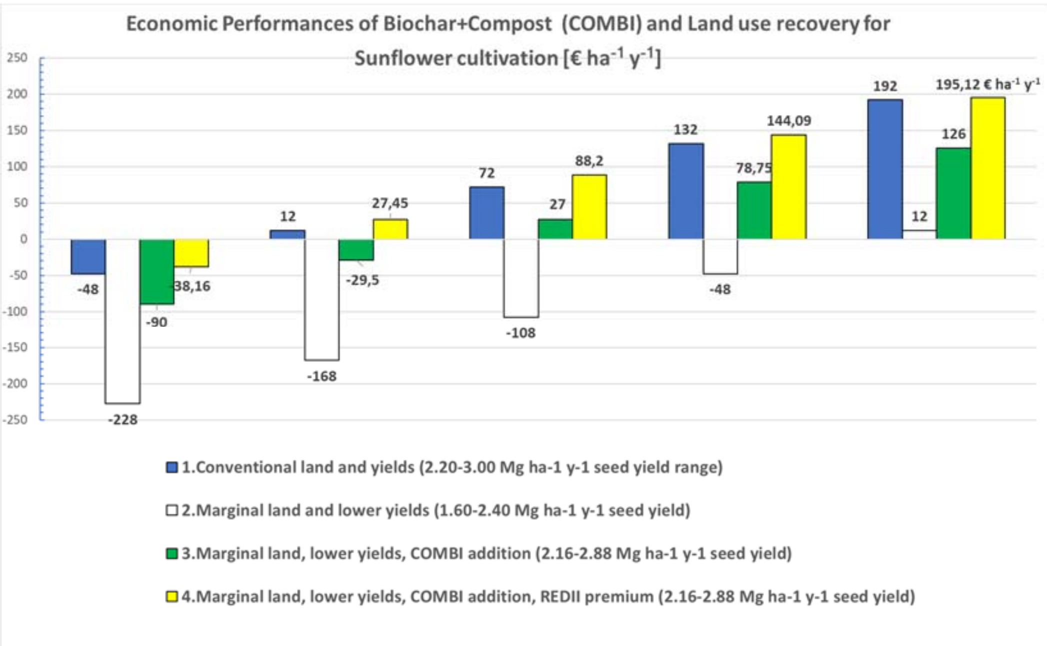

Figure 4: Estimated gross farm income with COMBI and various policy

4. Discussion

The investigation on conventional farming of Sunflower in the EU MED area shows that farmers have very small benefit from this crop: the real income that is generated becomes almost equals to the CAP support only under the highest yields, while on the contrary the profit is lower or even negative, when weather conditions or the type of soil, are unfavourable. Thus, either the farmer switches to a different drought-resistant crop, or the agricultural land is abandoned, given the unattractive economics.

Under these circumstances, adding biochar or biochar and compost (COMBI) improves crop yields and helps mitigate the climate change impacts. In particular, the use of COMBI provides both short-term and long-term benefit to the soil, adding readily available carbon and nutrients for crop cultivation in a reformed soil environment, increasing moisture content, and storing stable carbon. The use of COMBI also minimizes the amount of biochar addition per ha, thus reducing the support needed and allowing from multiple applications.

The analysis for COMBI considered even a rather small (and conservative) support from CAP (110 € ha^{-1} y^{-1}, for 5 years), compared to the case of biochar only (200 € ha^{-1} y^{-1} at an application rate of 5 Mg ha^{-1}). The use of compost in agriculture would also be stimulated, a widely available material not yet adequately exploited in several EU Countries despite its large potential.

Since current farmers' returns from sunflower cultivation in conventional land are ~120-200 € ha^{-1}, the study concluded that COMBI is the most promising approach, unless higher seed yields from biochar only can be achieved (it can happen, depending on the specific site and weather conditions).

As regards the cost for C sequestration, ~300 € Mg_C^{-1} were estimated, considering conservatively 70% fixed-C content in biochar: this figure determines ~82 € Mg_{CO2}^{-1}, a comparable and very similar figure to major Carbon Capture Sequestration (CCS) options (estimated in a range between very optimistic ~10 US$ Mg_{CO2}^{-1} and ≥ 100 US$ Mg_{CO2}^{-1} (Griscom et al, 2017; Rubin et al, 2017). Nevertheless, these CCS solutions do not bring the benefits of biochar as:

- more sustainable agricultural practices, towards circular economy;
- fight desertification of marginal areas, keeping the land available for food, feed and bioenergy production

However, biochar and compost only represent part of a possible approach to increase the resilience of marginal land to climate change effects, and a set of coordinated measures, especially on the water management side, will have to be considered and implemented. Moreover, a very effective control of the supply chain will be necessary, with innovative solutions to ensure that suitable and tracked materials are processed through slow pyrolysis and composting.

5. Conclusions

The analysis provided evidence that biochar, and in particular COMBI, use in EU MED marginal agricultural land is a possible solution to fight climate change, and that food, feed and bioenergy could be produced combining different policy instruments.

- The situation of the EU MED agriculture is becoming critical in very large areas due to climate effects, with a potential of 8.5 Mha under risk of marginalization. This fact represents a major concern in the EU, and a major reason for agricultural land abandonment, well documented over the last decades in many EU Countries.
- The use of biochar and compost (COMBI) solutions can contribute to mitigate these effects, promoting sustainable agriculture. Biochar can be produced from a variety of feedstock, both woody or herbaceous, and from dedicated or residual materials. Biochar can offer long-term positive effects by reconstituting the soil texture, improving its porosity, and favouring moisture retention and slow fertilisers release. COMBI brings additional benefits (in a short-term view), with crop readily available carbon and nutrients. This approach can be seen as a possible approach to generate a kind of "positive Land Use Change" effect, since agricultural soil is kept productive or recovered, instead of becoming deserted, with net loss of organic carbon and microbial life.
- Given the large area at risk of marginalization in the EU MED Countries, the potential impact of a biochar-based BECCS (BioEnergy and Carbon Capture and Storage) strategy in the EU MED is considerable: the theoretical potential equals ~156 Million Mg_{CO2} sequestered, almost 3.5% of total EU-28 GHG emissions (including international aviation and indirect CO2, excluding LULUCF) in 2015 (equal to 4451.8 Million $Mg_{CO2equiv}$), or more than 10% of EU MED (PT, ES, FR, I, HR, EL, CY) countries only (1471 Million $Mg_{CO2equiv}$) (Eurostat, 2017).
- To deploy at large scale the potential of biochar and, in particular, COMBI, in the EU MED region, policy support is needed: however, the present work found that several instruments already exist in the policy framework that could be effectively used to achieve the goal. These are mostly in the area of the Common Agricultural Policy, the Energy Policy, and the Climate Change Policy, even if also the Circular Economy policy could contribute.

• These will allow EU MED farmers to reach sufficient profit to continue their activities, preserving in this way the socio-economic equilibrium in these rural areas.

Nevertheless, given the very large range of results given in literature as regards biochar and COMBI addition, which strongly depends on the specific type of soil, the local climate, the type of cultivated crop, the characteristics of the specific biochar type under investigation, it is necessary to demonstrate the actual effectiveness of this biochar/COMBI-based at site-specific conditions. A dedicated programme is thus recommended to provide the necessary resources to carry out this evaluation in well selected EU MED regions.

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Glossary

CAP: Common Agricultural Policy
COMBI: blend of 80% w/w compost and 20% w/w biochar
COP: Conference Of Parties
EC: European Commission
EEA: Eur.Environment Agency
ETS: Emission Trading S
ILUC: Indirect Land Use Change
JRC: Joint Research Center
MED area: Mediterranean area
MS: Member State
RED: Renewable Energy Directive

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