Deliverable achievement report

[D3.4.1 Engage women- and youth-driven community enterprises in selecting the best practices]

[28/02/2024]

Summary

The two key options: compost and biochar

Compost

Compost production

Compost is an organic product that appears as a soil rich in woody plant debris, usable as a soil improver, derived from the decomposition (composting) of organic matter by microorganisms under controlled conditions. During this complex process, the transformation of a heterogeneous biomass into a homogeneous biomass similar to soil, rich in a colloidal substance with extraordinary properties, takes place.

To produce compost it's important to start from a well-balanced biomass mixture in terms of carbon/nitrogen ratio (the optimal one is around 30) and which must be adequately ventilated and wetted, to avoid the process stopping due to lack or excess of water and/or due to lack of oxygen. Raw organic materials for compost production are crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes.

Beneficial effects of compost

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physico-chemical and biological properties of the soil. As a result of these improvements, the soil: (i) becomes more resistant to stresses such as drought, diseases and toxicity; (ii) helps the crop in improved uptake of plant nutrients; and (iii) possesses an active nutrient cycling capacity because of vigorous microbial activity. These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers.

More in particular compost is capable of improving the soil from a chemical, physical and microbiological point of view and from a phytosanitary point of view:

- Chemical fertility is improved as macroelements (nitrogen, phosphorus and potassium) and microelements are provided which are more or less available for plant nutrition;
- Physical fertility is improved as a "glomerular" soil structure is promoted, capable of improving the relationship between aeration and water retention capacity of the soil, as well as its softness and workability;
- Microbiological fertility is improved as microorganisms capable of increasing the availability of nutritional elements for plants and producing substances with phytohormonal action that stimulate crop growth are stimulated.

The phytosanitary improvement brought about by composts is a consequence of both the direct contribution of antagonistic microorganisms, developed during the composting process, such as the thermophilic bacteria of the Bacillus genus (widely used in biological control), and as a consequence of the stimulation of the growth of microorganisms antagonists already resident in the soil. These microorganisms hinder the development of phytopathogenic bacteria and fungi that are preserved in the soil, through mechanisms of competition for space and nutrients and the production of antibiotic substances. Even the aerial part of the plants appears to be more protected, thanks to phenomena of resistance induction in crops, due to the action of specific microorganisms that develop around the roots. The most effective composts in controlling plant diseases, i.e. the most "suppressive" ones, are often richer in aromatic substances with a microbicidal action derived from the ligno-cellulosic matrices placed in the pile to be composted.

Types of composting

Composting may be divided into two categories by the nature of the decomposition process: anaerobic or aerobic composting. While in anaerobic composting (when decomposition occurs where oxygen is absent or in limited supply) drawbacks often offset the merits (e.i. longer process, strong odours, phytotoxicity, it leaves weed seeds and pathogens intact), anaerobic composting, in which composting takes place in the presence of ample Oxygen , aerobic microorganisms break down organic matter and produce carbon dioxide (CO2), ammonia, water, heat and humus, the relatively stable organic end product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic micro-organisms decompose them further. The resultant compost, with its relatively unstable form of organic matter, has little risk of phytotoxicity. The heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemi- cellulose. Hence, the processing time is shorter. Moreover, this process destroys many micro- organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient and useful than anaerobic composting for agricultural production.

Factors affecting aerobic composting

Aeration: Aerobic composting requires large amounts of O, particularly at the initial stage. Aeration is the source of O, and, thus, indispensable for aerobic composting. Moreover, aeration removes excessive heat, water vapour and other gases trapped in the pile. Heat removal is particularly important in warm climates as the risk of overheating and fire is higher. Therefore, good aeration is indispensable for efficient composting. It may be achieved by controlling the physical quality of the materials (particle size and moisture content), pile size and ventilation and by ensuring adequate frequency of turning.

Moisture: Moisture is necessary to support the metabolic activity of the micro-organisms. Composting materials should maintain a moisture content of 40-65 percent. Where the pile is too dry, composting occurs more slowly, while a moisture content in excess of 65 percent develops anaerobic conditions. In practice, it is advisable to start the pile with a moisture content of 50-60 percent, finishing at about 30 percent.

Nutrients: Micro-organisms require C, N, phosphorus (P) and potassium (K) as the primary nutrients. Of particular importance is the C:N ratio of raw materials. The optimal C:N ratio of raw materials is between 25:1 and 30:1 although ratios between 20:1 and 40:1 are also acceptable. Where the ratio is higher than 40:1, the growth of micro-organisms is limited, resulting in a longer composting time. A C:N ratio of less than 20:1 leads to underutilization of N and the excess may be lost to the atmosphere as ammonia or nitrous oxide, and odour can be a problem. The C:N ratio of the final product should be between about 10:1 and 15:1.

Temperature: The process of composting involves two temperature ranges: mesophilic and thermophilic. While the ideal temperature for the initial composting stage is 20-45 °C, at subsequent stages with the thermophilic organisms taking over, a temperature range of 50-70 °C may be ideal. High temperatures characterize the aerobic composting process and serve as signs of vigorous microbial activities. Pathogens are normally destroyed at 55 °C and above, while the critical point for elimination of weed seeds is 62 °C. Turnings and aeration can be used to regulate temperature.

Lignin content: Lignin is one of the main constituents of plant cell walls, and its complex chemical structure makes it highly resistant to microbial degradation. This nature of lignin has two implications. One is that lignin reduces the bioavailability of the other cell-wall constituents, making the actual C:N ratio (viz. ratio of biodegradable C to N) lower than the one normally cited. The other is that lignin serves as a porosity enhancer, which creates favourable conditions for aerobic composting. Therefore, while the addition of lignin-decomposing fungi may in some cases increase available C, accelerate composting and reduce N loss, in other cases it may result in a higher actual C:N ratio and poor porosity, both of which prolong composting time.

Polyphenols: Polyphenols include hydrolysable and condensed tannins (Schorth, 2003). Insoluble condensed tannins bind the cell walls and proteins and make them physically or chemically less accessible to decomposers. Soluble condensed and hydrolysable tannins react with proteins and reduce their microbial degradation and thus N release. Polyphenols and lignin are attracting more attention as inhibiting factors. Palm et al. (2001) suggest that the contents of these two substances be used to classify organic materials for more efficient on-farm natural resource utilization, including composting.

pH value: Although the natural buffering effect of the composting process lends itself to accepting material with a wide range of pH, the pH level should not exceed eight. At higher pH levels, more ammonia gas is generated and may be lost to the atmosphere.

The aerobic composting process

The aerobic composting process starts with the formation of the pile. In many cases, the temperature rises rapidly to 70-80 °C within the first couple of days. First, mesophilic organisms (optimum growth temperature range = 20-45 °C) multiply rapidly on the readily available sugars and amino acids (Figure 1). They generate heat by their own metabolism and raise the temperature to a point where their own activities become suppressed. Then a few thermophilic fungi and several thermophilic bacteria (optimum growth temperature range = 50-70 °C or more) continue the process, raising the temperature of the material to 65 °C or higher. This peak heating phase is important for the quality of the compost as the heat kills pathogens and weed seeds.

The active composting stage is followed by a curing stage, and the pile temperature decreases gradually. The start of this phase is identified when turning no longer reheats the pile. At this stage, another group of thermophilic fungi starts to grow. These fungi bring about a major phase of decomposition of plant cell-wall materials such as cellulose and hemi-cellulose. Curing of the compost provides a safety net against the risks of using immature compost such as nitrogen (N) hunger, O deficiency, and toxic effects of organic acids on plants.

Eventually, the temperature declines to ambient temperature. By the time composting is completed, the pile becomes more uniform and less active biologically although mesophilic organisms recolonize the compost. The material becomes dark brown to black in colour. The particles reduce in size and become consistent and soil-like in texture. In the process, the amount of humus increases, the ratio of carbon to nitrogen (C:N) decreases, pH neutralizes, and the exchange capacity of the material increases.

On-farm compost production

On-farm composting takes place in the agricultural sector and may use a combination of crop residues, manure, straw, and other feedstocks generated on the farm to create compost. Farms may also choose to take in materials from residents or businesses in the surrounding community to increase their compost production or generate revenue in tipping fees. The compost produced can be used on the farm and reduce the need to purchase soil amendments and fertilizers. Selling compost can diversify a farm’s revenue streams.

What can be composted?

In principle, any organic product can be composted but crop residues or manure from livestock farms are excellent matrices to compost. Obviously, residues from the processing and transformation of agricultural products are also excellent material for composting, as are any unsold agricultural products. Generally, the aforementioned materials are easily compostable (nutritional material) but, ligno-cellulosic material must always be added to them (pruning residues, wood chips, walnut and hazelnut shells, etc.), having a "structuring" function.

The latter material is much more slowly degradable but essential for giving a non-compact structure to the pile, so as to favor the circulation of air within the pile itself. Not all materials of inorganic origin are compostable.

To create a good pile of biomass to compost it is necessary:

- mix 30-40% by volume of "structuring" material (wood chips, small twigs, leathery leaves, dried fruit shells, etc.) into the mass to be composted, having the function of giving porosity to the pile, avoiding its excessive compaction;
- mix into the mass 70-60% by volume of "nutritional" material to be composted (leaves, fruits, herbaceous stems, fleshy roots, tubers, manure, etc.);
- add mature compost as a starter, sprinkling it on the pile (2% by volume);
- create mounds with a trapezoidal section, as long as you want but 2-3 m wide and 1-1.5 m high;
- ensure adequate ventilation of the piles. Aeration can be achieved by periodically turning the piles, or even without turning them but still ensuring forced insufflation of air underneath them. Alternatively, aeration can also be implemented by creating very porous piles. These three aeration systems represent three composting systems which are described in more detail in the following paragraphs;
- ensure adequate wetting of the piles. In essence, it is necessary to ensure that the pile is always moist but never soaked in water or too dry (if you squeeze a handful of material in one hand, this must remain adherent to the hand appearing plastic, without releasing free water or appearing dry and incapable of adhere to the hand itself);

- build the mounds on a waterproofed platform (thick waterproof tarpaulin or concrete platform) and keep the mounds covered to protect them from the weather. To repair the piles, canopies or greenhouse-tunnels can be built; alternatively, the piles can be covered using waterproof sheets or non-woven fabric.
- To ensure that composting occurs without problems, you need to check whether:
  - there is a rise in temperature up to 60-65 °C within 24-48 hours from the creation of the pile. For this reason it would be a good idea to get a thermometer to check the temperature in the heart of the pile. Without prejudice to the correct aeration and wetting, especially if the C/N ratio is high enough, the start of the pile, evidenced by the rise in temperature, can be delayed by a few days;
  - the heap does not emit bad odors and does not produce smelly dark leachate. The latter two phenomena are due to a lack of oxygen, which can occur as a result of reduced aeration or an excess of water in the pile.
  - if the pile loses too much water, composting stops. To avoid this, water the pile periodically - but not excessively.

Composting methods

Turned wind-rows composting

With this system, aeration is ensured by turning the piles a couple of times a week for approximately 4-6 weeks, that is, until, after turning the biomass, there is no longer the characteristic rise in temperature of the pile. Temperature increase indicates that there is still organic material that must be transformed by microorganisms.

After this "active" phase, the pile will undergo a maturation phase which will last, on average, another couple of months. During maturation there is no need to turn the pile which can therefore be left somewhere protected from rain and sun. Turning can be carried out using manual or mechanical shovels or using special turning devices, which are commercially available and can be connected to the power take-off of tractors.

Aerated static pile (with forced air insufflation)

I order to avoid periodically turning the biomass to ensure aeration and, at the same time, have a compost mature in a shorter time, it is possible to create static piles ventilated in a forced way. The forced insufflation of air can be achieved by means of a fan or a compressor which periodically injects air (which supplies oxygen) into rubber pipes suitably perforated every 15-20 cm, placed underneath the piles. Typically, 5-10 minutes of insufflation every 3-4 hours is sufficient. In detail, the devices necessary to create an "on farm" composting plant of this type are: 1. Composting and storage platform; 2. Air blowing system, consisting of fan, timer and perforated pipes; 3. Irrigation system for wetting the pile; 4. Probes for measuring the temperature in the pile.

Passively aerated static pile (with passive diffusion of air)

With the latter system, oxygen reaches the mass through diffusion and natural ventilation. In this case the composting process is slower (it can last several months) but it is still possible to obtain excellent quality compost, because it is richer in humus. Obviously it is always necessary to ensure correct wetting of the biomass and check the correct temperature trend and the absence of bad smells. The quality of a compost depends on the nature and mixing of the starting plant matrices and the composting process. One technique is to create static piles by placing them in a slotted box made of wood or with a wire mesh a few centimeters wide, alternating layers of structuring material and nutritional material, each a few centimeters high.

Fig. 2: small-sized pilot plant for compost production (passively aerated static pile)

Evaluation of compost quality

If the instructions previously described are generally respected, within 3 months - in the case of a turning heap or a forced air insufflation heap - you will have good quality compost; in the case of a static pile with passive air insufflation, the waiting times are at least double. In any case, a well-mature compost ready to be used in agriculture must have the appearance of a more or less dark soil and more or less rich in woody plant fragments, and must have a pleasant and non-pungent scent, as this The latter indicates an excess of ammonia (phytotoxic, i.e. harmful to plants). To have direct proof of the goodness of a compost, simple phytotoxicity tests can be carried out. Generally, these tests consist of germinating watercress seeds periodically moistened with an extract in a container with a low edge (even an upside down lid of a jar is fine).

aqueous mixture of compost obtained by vigorously shaking 50 grams of compost in a liter of water in a glass container for a few minutes. Within a few days, it is observed whether the development of the roots and the stem with the leaves occurs similarly to what is recorded in another container whose seeds have been periodically wetted with tap water.

If the development of the rootlets is similar or superior to what is observed with water alone, then the compost is ready to be buried; otherwise, it is best to wait another month for maturation and then repeat the test. In addition to carrying out the test using the aqueous extract of compost as is, it is advisable to also carry it out using it at dilutions of 1:3 and 1:10 and always observing the development of the rootlets compared to a control with water.

A small-sized pilot plant for compost production for Mountain-Her project should have the following characteristics:

- Cement slab of approximately 500 m2, of which half occupied by concrete slab and the remaining half arranged with gravel and compacted soil. The concrete platform should identify 2 areas of equal size: the first, intended for the implementation of the active phase of composting, with a slope of 2%, having a slotted floor at the end and underground ducts to convey any leachates to a collection well; the second area should be intended for the handling/shredding//mixing of the matrices to be composted.
- Air blowing system into the pile. It consists of a professional high pressure vacuum cleaner, with three-phase asynchronous motor (230/400V) suitable for continuous service, flow rate 1850 m3/h, absorption 2.8 A, power 1.1 kW; b) pipes, T-shaped dividers, polyethylene curves and shutters, combined in such a way as to define an air distribution network in sectors, flexible and perforated in the portion involving the piles; c) gate valve and air insufflation pipe into the collection well for the oxidation of any leachate.
- Electrical system and temperature measurement and control system for the composting process.
- irrigation system. The hydration of the matrices can be carried out using an irrigation system limited to a single sprinkler nozzle placed at the end of a polyethylene pipe connected to the company or consortium water network.

Biochar

Biochar production

Biochar is a material rich in carbon that results from the pyrolysis of any biosolid material such as wood, fruit shells, residues of plants, manure, industrial and municipal waste, sewage sludge, farming, and fermentation residuals. Biochar remains in the soils for thousands of years and it is therefore considered more resistant to decomposition than organic matter, acting as an important long-term carbon sink

The application of biochar on soil has both direct and indirect effects on fertility. The direct effects include an enhanced nutrient availability (potassium [K], phosphorus [P], calcium [Ca], magnesium [Mg] and sulphur [S]), while indirect effects are through the improved physical, chemical, and biological properties of the soil (increases in soil pH, cation exchange capacity, mineral nitrogen (N) availability, microbial diversity, increases in water holding capacity and porosity)

Biochar is produced by heating biomass in the total or partial absence of oxygen. Pyrolysis is the most common technology employed to produce biochar, and also occurs in the early stages of the combustion and gasification processes. Besides biochar, bio-oil and gas can be collected from modern pyrolysers.

Input: biomass characteristics and requirements per unit of time

The pyrogasifier can be powered with different types of biomass (including waste and wet biomass which would otherwise be burned or destroyed). In particular, biomasses coming from the agroforestry sector can be used (for example grass cuttings, branches, pruning residues, wood chips, hemp - the woody part of the hemp stem -, bovine/pig digestate - however it must be mixed with woody material - by-products of the wine supply chain, tomato peels, etc.).

To be usable in the plant the products must have the size of wood chips, for this reason in the hypotheses relating to the investment the purchase of a hammer chipper is envisaged.

The plant uses 20-25 kg of dry biomass per hour, which, considering an operation of 330-340 days a year (for the remaining days the plant must be stopped for cleaning and maintenance operations) translates into potential of 200 tons of biomass.

Outputs, their yields and their possible uses

The pyrolyzer produces electricity, steam, heat and/or cold and biochar.

The yield of the various outputs depends on the material used, it is maximum with wood chips while with agricultural waste biomass (e.g. straw) the yields are lower and require mixing with pellets.

By equipping the plant with a Stirling engine (an external combustion engine of the reciprocating motion type) and orienting the plant towards the production of electricity, it is possible to obtain 18-25 KW of energy per hour and a residual of thermal energy per 35-40 KW (the values depend on the calorific value of the biomass used).

Thermal energy is produced in the form of heat or steam/hot/superheated water (which can possibly be used for heating or for example for cleaning, sanitization and sanitization operations).

The biochar yield varies from 10 to 20% of the biomass input, in relation to the humidity and its characteristics. In particular, wood chips are the ones that have the highest yields in biochar, while very humid biomass and other waste biomass (e.g. straw...) have much lower yields (in the case of straw, the percentage also comes into play to the detriment of of ashes).

Considering a year of work with mixed biomass, a pyrolyzer can potentially produce 30 tons of biochar in a year.

The biochar produced is in line with the legislation on soil improvers and furthermore (this depends on the characteristics of the starting biomass) tends to be in granular form and therefore easy to handle and distribute on the ground. For the distribution of biochar it is necessary to have a manure spreader.

Potential impact on the carbon cycle

The compact structure of biochar allows this product not to be degraded by soil microorganisms and therefore to store carbon instead of returning it to the atmosphere in the form of CO_2 as in the case of compost or the combustion of pruning residues (Kuhlbusch et al. 1996; Lehmann et al. 2002; Harris and Hill, 2007).

The application of this product to the soil also has direct influences on the reduction of natural CH_4 and N_2O emissions as it modifies some parameters of the matrix and consequently the metabolic activity of particular microbial communities responsible for the production of these compounds.

The biochar produced by a plant, considering only internal use, can in fact be distributed on company land. The use dose is approximately 15 t/ha, so 2 hectares in rotation every year would be sufficient to dispose of a production of 30 tons.

30 tons of biochar make it possible to sequester around 70 tons of CO_2 from the atmosphere (to get an idea, a medium-sized diesel car that travels 20,000 km/year emits 2 tons of CO_2 and a person considering all his activities emits on average 10 tons of CO_2 in a year).

Furthermore, the use of the pyrogasifier allows:

- to use, thanks to the distribution of biochar, smaller quantities of fertilizer, which corresponds to a smaller quantity of CO_2 emitted in the relative production: this figure, however, is the balance between the emissions avoided thanks to the lower quantity of fertilizer used thanks to the action of biochar, and the emissions linked to the supplementary organic fertilizer to be used on the land, to replace the biomass not left on the land because it was sent to the pyrogasifier;
- to use self-produced electrical and thermal energy, thus avoiding the emission of CO_2 linked to the production of methane or equivalent electrical current in other ways;
- if the pyrogasifier is located near the fields or the place where the biomasses are usually stored, the balance should also consider the CO_2 not emitted, for example, by the transport of the biomasses to a biogas plant.

The CO_2 balance should therefore take into account the factors mentioned above and, with the opposite sign:

- the CO_2 emitted by the pyrogasification plant;
- one-off, of the CO_2 emitted for the construction of the plant (metals, cement...). Considering a useful life of the system of 15 years, 1/15 of the emission per year can be considered;
- of the CO_2 "emitted" relating to any organic fertilization carried out to compensate for the use of biomass otherwise left in the field in the pyrogasifier;
- of the CO_2 emitted by biomass chipping machines when necessary;

- the CO_2 possibly emitted for the transport of biomass to the pyrogasifier, evaluated based on the transport capacity of the vehicle, the number of trips, the fuel consumption per km of the vehicle and the type of fuel used;
- the CO_2 emitted for the transport of biochar.

Finally, it should be considered that the biomass left in the field, whether it is left on the surface or chopped and buried, will release a good part of the carbon previously stored in the atmosphere within 1-2 years. This release occurs only in part, with the passage through the pyrogasifier, due to the carbon retained in the biochar.

Minimum investments

The main investment items envisaged for the installation of a pyrogasification plant are:

- pyrogasifier system, connections, structures, including the cyclone separator filter, which allows to reduce the emissions of the system
- hammer chipper to transform biomass into wood chips where necessary
- possible adaptation of buildings
- other structures and systems to manage inputs (biomass storage) and outputs (biochar, use of energy sources)
- any other investments to benefit as much as possible from the outputs (situations that benefit from biochar and energy).

Costs

The use of a pyrogasifier generates the following costs:

- work necessary to monitor feeding and manage biomass
- annual and extraordinary maintenance (every 5 years)
- energy consumption (self-consumption, for example of control panels, etc.), to be deducted from the energy produced;
- lack of alternative use of biomass, if it could alternatively be sold or used for biogas, etc.
- possible cost of organic fertilizer to be used on the land to replace the biomass not left on the land because it was used in the pyrogasifier
- possible purchase of pellets or shredded wood to rebalance the humidity of the biomass used
- possible purchase of additional biomass in addition to that produced, to saturate the capacity of the plant and complete the 8000 hours of annual operation
- cost of transporting the biomass to the pyrogasifier.

Revenues

How does a pyrogasifier generate revenue?

- producing thermal and electrical energy, therefore resulting in a loss of electricity costs or revenue if they were sold;
- producing biochar, which in turn generates an increase of approximately 10% in the yield of many crops;
- alternatively (or partially), biochar can be sold;

- through contributions in the form of “carbon credits” (the value of which is extremely volatile, and requires investments for certification and management);
- through TEE (energy efficiency certificates or white certificates, also in this case with variable value over time also due to ongoing regulatory developments).

Pilot plant characteristics

A small-sized pilot plant for the carbonization of biomass was taken into consideration, suitable for the needs of a small and medium-sized company.

Thanks to this system it is possible to abandon the concept of cogeneration understood as the combined production of electrical energy and heat which has governed the development of these plants up to now and to broaden it to that of polygeneration (production of biochar, electrical energy, steam, heat and /or cold), valorising residues from the agri-food and agroforestry sector, according to a circular economy model.

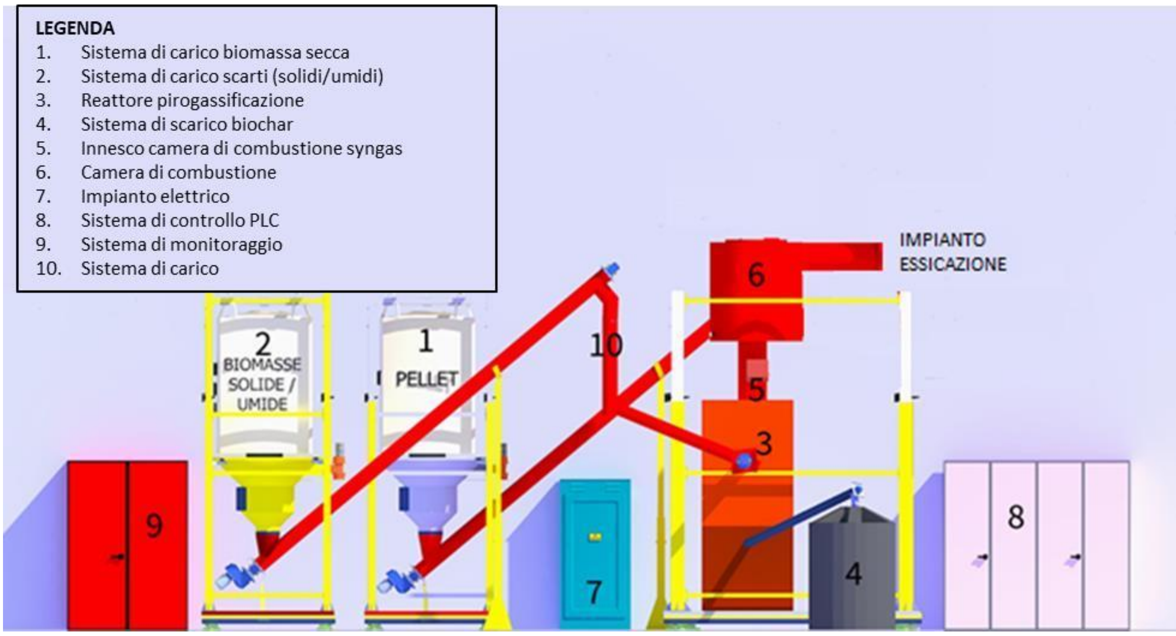

Fig. 1: Schematic representation of a pilot plant

The prototype plant is complete with a double biomass loading system:

- the first for the initiation phase and possibly for the phase of raising the thermal potential, with dry materials;
- the second, suitable for loading biomass, even semi-solid to palatable, deriving from cultivation/processing processes, of which chemical-physical analyzes will be evaluated for the definitive sizing.
- The multiple and simultaneous feeding allows the use of different types of biomass as they are (with humidity even above 60%). This versatility is suitable for a large number of potential uses as it does not require pre- and post-treatment systems for the feeding material. Furthermore, it allows to increase the process energy yield (thermal and electrical) if necessary.

The system, the principles and the components that make up the pyro-gasifier (one of a kind) are covered by an international patent.

The prototype plant in question (patented micro-pyrolyzer) was created to be able to valorise the by-products (organic biomass), mainly from the agri-food chain, as they are without particular preparations, to produce electrical and thermal energy to be used in the production cycles of the same production chain. Thanks to the oxidation of the bio-syngas produced, and with the production at the end of the process of a soil improver for agriculture (biochar), capable of sequestering carbon dioxide, a very high efficiency polygeneration is obtained.

It is a modular system with power depending on the organic biomass introduced and the degree of humidity.

The fact that it is a small prototype plant has an effect on the value of the investment necessary for its purchase, which is higher than it would be for a larger plant (whose components are more widespread on a commercial level) or when production of the small version was expanded.

The plant, designed for the carbonization (pyro-gasification) of the resulting materials, produces a biochar which, from the analyzes and studies conducted in Emilia-Romagna, shows a very low percentage of polycyclic aromatic hydrocarbons, largely respecting the physical-chemical parameters of the recent national legislation (D.L.: G.U. 186 12.08.2015). This occurs thanks to the use of particular measures, the subject of the patent, which favor energy recovery and process optimization. These results also confirm the production of positive effects on soil fertility and the increase in organic carbon content in a stable and long-lasting way, making this technology promising and recognized globally for carbon sequestration in terrestrial ecosystems and the mitigation of changes current climate.

The system is supplied complete with an electronic system with PLC, with remote control, which allows remote management and control of the system, allowing continuous and constant monitoring. Sensors capable of characterizing emissions are being implemented.

The pyrogasifier can produce electricity, thermal energy and Biochar (coal) that can be used as an agricultural soil improver.

Plant management

The pyrolyzer must be positioned if possible in a closed shed (or at least under a roof) with an available space of at least 100 m2 (both for the system and for input and output storage).

The plant is supplied "turnkey", for its operation it requires a commitment of one hour every two days, the time necessary to replace the big bag with wood chips and unload the biochar (plus obviously the time necessary for the preparation of the biomass, an operation which however can be carried out at longer intervals).

To be economically sustainable and also for technical reasons, the plant must work all year round with some periodic breaks necessary for cleaning the plant and maintenance. The maximum effective operating days can be quantified as 330-340/year (8,000 hours).

Since the plant operates best with an input humidity of less than 20%, it could be envisaged, at a later stage, using part of the heat produced to dry the biomass itself. For the purposes of this simulation, "natural" drying is assumed, also taking into account the fact that the biomass is not all used in the period in which it is produced, and a storage system can be envisaged that favors its drying.

The interviews carried out within the Project participants

An initial survey was carried out to understand what use of the farm waste is currently done and what machineries are available to carry it out. The survey included three section:

- *What kind of farm waste do you produce in the farms of your Cooperative? Please select the type of waste your produce, and, for the selected types, add the amount produced each year and the size of the field*
- *Please describe how farm waste are currently being used*
- *Please describe any machinery/tool available in the farm/cooperative for the waste treatment/processing*

The interviews carried out showed a plurality of situations in terms of farm size, types of biomass available and current management practices.

- **Italy** identified the Farm to be converted into a community enterprise to produce nonsynthetic fertilizers and performed the Initial survey. The farm has availability of Yard clipping and Pruning residues. Currently those waste are left as they are in the field. The farm own a shredder.
- **Croatia** identified the Farm to be converted into a community enterprise to produce nonsynthetic fertilizers and performed the Initial survey. The farm has availability of manure, green manure, Yard clipping and other fresh remains. Currently those waste are used in the field as they are. The farm doesn't have a proper machinery to produce compost but can rent.
- **Lebanon** identified the Farm to be converted into a community enterprise to produce nonsynthetic fertilizers and performed the Initial survey. The farm has availability of manure, straw and grape dregs. Currently those waste are used in the field as they are or dried. The farm doesn't have a proper machinery to produce compost but can rent.
- **Marocco** identified the Farm to be converted into a community enterprise to produce nonsynthetic fertilizers and performed the Initial survey. The farm has availability of manure. Currently those waste are used in the field as they are. The farm doesn't have a proper machinery to produce compost but can rent.
- **Algeria** identified the Farm to be converted into a community enterprise to produce nonsynthetic fertilizer.
- **Tunisia** identified the Farm to be converted into a community enterprise to produce nonsynthetic fertilizer.

What emerges is that the size of the system, although modest, could be too large for a medium-small sized agricultural company, and still requires:

- financial availability for the investment;
- time to dedicate to the management of biomass (additional in the event that the biomass itself is, at the moment, left on the ground or buried, but also sent to a biogas plant which has organised, for example, its collection). In fact, these must be stored (to be available all year round), sometimes dried, chipped;

- methods of use / transfer of electricity and/or thermal energy (in what form: hot water? district heating? to which recipients: public or private entities?)

The guideline was done, as a transversal document for business models and business plans as a basis for training.

Justification of delay

No delay

Supporting documents

- Task 3.4 Circular economy approaches for community-based fertilization solutions: Survey to understand what is currently being done with farm waste and what machinery is available to do it.
- *Excel file for calculations*
- *The guideline for business models*

MOUNTAIN HER

Empowering women in mountain farming communities

PRIMA

PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA