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Action 4 – Development of alternative agricultural practices – Lab experiments (Italy)

Deliverable "Guide for open field and greenhouse cultivation of the tested crops (Italy)"

Prepared by: Chemical Laboratory of Chamber of Commerce, Industry, Agriculture and Handicraft of Savona

Coordinator: Dr. Luca Medini
Chemical Laboratory of Chamber of Commerce, Industry, Agriculture and Handicraft of Savona
Regione Rollo 98 - 17031 Albenga (SV)
Tel. / Fax: +39 0182 - 50960
email: luca.medini@labsvcamcom.it

Reviewed by: Dr. Federico Tinivella, Ce.R.S.A.A., Albenga, Italy
Prof. K. Komnitsas (project coordinator)

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1. Executive summary

In the line of Action 4, pot trials were carried out in order to assess the suitability of two kinds of composts for the cultivation of different plant species. As indicator cress (*Lepidium sativum*) was chosen. Such composts were selected through chemical analysis (see Deliverable: "Characterization of wastes treated by different technologies regarding their suitability for agricultural use and especially for vegetable and ornamentals cultivation under Italian climatic conditions") and specific tests to identify any hazardous compounds with regards to Italian relevant legislation and, consequently, their suitability for plant cultivation. The composts belong to two categories that are codified by the Italian legislation (D.lgs. 29 aprile 2006 n 217 and annex update DM 22 gennaio 2009) as "Ammendante compostato misto" (English non official translation "Mixed composted soil improver") and "Ammendante compostato verde" (English non official translation "Plant composted soil improver"). **Both composts were provided by Centro Sperimentale di Compostaggio - Ente Parco Nazionale Del Cilento E Vallo Di Diano, Laurino (Salerno), coordinating beneficiary of the LIFE project "Tirsav plus"** (www.tirsavplus.eu). The outcomes of the pot trials were used as a basis for the set up of field trials foreseen in the subsequent phases of Wastereuse project in terms of kind and doses of producing factors for the proper management of selected vegetables and ornamental species on a large scale.

According to the results obtained and a dedicated bibliographic search, indications are given in the present report regarding the possibility to use composts as growing media when mixed at different rates together with other kind of materials. Use of composts is evaluated according to main chemical properties and agronomic performance when used for the cultivation of different kind of crops (both in open field and greenhouse). Results show that blends of natural soil and good quality compost mixed in proper ratios (20 % to 40% of compost v/v) together with zeolite can be used in the place of traditional peat based growing media with specific regards to pot cultivations.

2. Introduction

The objective of Action 4 is the evaluation of processed solid wastes (composts) and wastewaters as derived from different methods/technologies in order to define their suitability as growing media, i.e. their capacity to promote crop production and quality with regards to plant species used as indicators.

Through an extensive survey, different kind of wastes (untreated OMWW, treated OMWW, olive pomace, composts, wine lees, manure, rice hull) were analysed for their chemical characteristics and for their agronomic properties i.e. the suitability of promoting plant growth. Some wastes were selected because of the absence of hazardous components and the absence of phytotoxicity assessed on cress in *in vitro* tests. Two kinds of composts were then promoted to be used in pot tests where both natural soils and commercial growing media were amended with them at two different rates. Additionally, zeolite (clinoptilolite) was used to enrich the growing media because of its characteristics when applied as soil amendment: reduction of irrigation need, reduction of fertilizer input, retention of nutrients in root zone, improvement of aeration, buffer potential in case of acidic soils (Doula et al., 2012).

The overall objective was therefore to evaluate the possibility to set up alternative cultivation practices through preliminary tests carried out in pots in order to potentially apply them in further open field trials or larger pot trials on different plant species.

The use of compost as component of growing media is established since many years because of its characteristics that involve not merely a general improvement of the substrates used for the cultivation of potted plants but, more in general, the contribution to a higher environmental sustainability of the entire sector.

Intensive efforts are necessary to close material loops as far as possible in order to counteract effectively the increasing shortage of important economic and valuable resources for the maintenance of soil fertility in agriculture, landscaping and horticulture. Besides the protection of finite nutrient reserves, first of all phosphorous, is it necessary today to maintain the humus contents of garden soils and in arable land on a sufficiently high level in order to guarantee their usability and to achieve high and qualitatively first class yields on a long-term basis.

Professionally produced composts proved to be suitable resources in order to cover the high demand for the cultivation of soils used in horticulture and agriculture - besides traditional sources like fertilisers from animal origin or straw and green manure. They are used more and more to improve soils and for fertilisation, mainly on farms without other alternative organic fertilisers.

At EU level the annual overall production of compost is around 10,2 million tons, i.e. around 20 millions m^3 (Zaccheo and Cattivello, 2009). In EU 27 around 90% of the compost is produced in just 7 countries (Germany, France, United Kingdom, Denmark, Netherlands, Belgium, Italy). The main use of compost is related to the agricultural sector (Table 1) as improver to replenish the organic matter content of the soil. Only 15% of the overall production of compost is used for the production of growing media (Barth, 2008)

Table 1 – Market shares of compost in Europe and in Italy according to the different sectors (modified from Barth, 2008).

Sector	Market shares Europe (%)	Market shares Italy (%)
Agriculture	45-78	62
Horticulture	3-15	
Landscaping	6-20	33
Growing media	10-15	
Gardening (hobby)	12-20	
Environmental recovery	2-10	5
Export	6-7	

It is estimated that compost is used as a component of growing media by 1,5 millions tons/year, i.e. around 3 millions m^3 considering a density of 500 kg/m^3.

The use of compost in growing media is justified by different positive characteristic which are listed hereby (Centemero, 2009):

- Compost is a renewable resource;
- CO_2 emission related to the production of composts is lower than the one related to peat extraction and processing (A.A.V.V., 2005);
- It is easily available in Italy;
- It is normally cheaper than peat;
- It has a steady texture that derived from a defined sieving (0-10 mm);
- It allows cost saving when producing growing media;
- It has agronomic properties which are complementary to peat's ones;
- It is an organic component characterized by an interesting buffer potential;
- It is an active substrate from a microbiological point of view that can promote the suppressiveness of the growing medium.

3. Composts suitable for agricultural use

In the last years the amounts of compost used in open field or in greenhouse for the cultivation of different crops has increased due to their known role in providing nutrients to substrates. On the whole, humic substances and, more in general, the organic matter contained in the composts can play essential roles when incorporated in the soil (Inbar et al., 1990), since they:

- promote the build up of soil aggregates, improving soil structure (enough porosity and water holding capacity) and favouring tillage, set up of sowing bed and root penetration;

- increase the exchange capacity of main elements;
- promote the exchange of nutrients between soil and plant;
- avoid a too intense run-off;
- decrease soil erosion;
- control the humidity of the soil horizon interested by the root system;
- contrast phenomena that concur to soil desertification with particular regards to farm land.
- improve the action of microfauna and microflora.

When considering the cultivation of plant species and, specifically, of potted plants ACV and ACM are normally taken into consideration with regards to their agronomic properties:

ACV (according to D. lgs. 217/2006): they show interesting properties from a physical/hydrological point of view and they normally have a lower salinity with regards to other typologies of composts (that is important when considering interactions between substrate and rhizosphere). Applications of ACV is therefore simplified for what concerns ornamental species production and it is normally adopted at home level as growing medium mixed with peat. In case ACV is produced from leftover plant parts with a high woody content, normally nutrient content is low (especially N, P and K). Therefore such compost mainly fulfils the role of "soil improver" thanks to the capacity of providing humified organic matter.

ACM (according to D. lgs. 217/2006) – they are composed by materials deriving from animal husbandry, food residues, sewage sludge and they can provide nutrient elements in addition to organic matter, in this way acting as real fertilizers. Normally composts deriving from food wastes are rich in Mg and Fe while the ones deriving from sewage sludge have a higher content in P. For instance, horticultural production as well as fruit and vine cultivation (in case of re-implantations) take advantage from the nutrient properties of such kind of compost. Moreover they can be applied in organic farming – a productive sector which normally envisages the exclusive organic fertilization – gardening and landscape planning when new plant establishment are considered. On the contrary the high content in soluble salts limits a large use of them for the production of e.g. potted flowers.

Valorisation of composts is necessarily based on the assessment of selected analytical parameters that can influence the choice of compost for certain uses rather than others. With regards to the production of potted plants key parameters are: pH, EC, physical/hydrological properties and content in soluble elements. In Table 2 relevant importance of different parameters are presented with regards to different uses.

Table 2 – Relevant significance of some parameters with regards to kind of use (Centemero, 2009).

Parameter	Professional growing media	Gardening and landscaping growing media	Soil conditioner and organic fertilizer	Mulching
Phytotoxicity	+++	++	+	-
pH and EC	+++	++	+	-
Physical/hydrological properties	+++	++	-	-
Impurities/contaminants	+++	+++	+	+
Colour and odour	+++	+++	+	+
Size	+++	++	+	+

- = no importance; + = low importance; ++ = medium importance; +++ = high importance

It appears that the use of compost as a component of growing media at professional level imposes the need of more sever controls during both the production phase and during the mixing phase with other components.

It is also possible to compare main properties of compost and peat to an "ideal" growing media in order to get a deeper view about their suitability as growing media (Table 3) (Centemero, 2009).

Table 3 – Physical and chemical properties of peats and composts put in comparison.

Parameter	Sphagnum peat	Ideal growing medium	ACV	ACM
Apparent density (g/cm^3)	0,6-0,1	0,15-0,50	0,35	0,4
Total porosity (% v/v)	>96	>85	80-85	80-85
Air capacity (% v/v)	5-50	20-30	25-30	25-30
Available water (% v/v)	24-40	24-40	12-15	14-16
pH	2,5-3,5	4,5-6	7,5-8,0	7,8-8,3
EC (dS/m)	0,2-0,4	<1	1	2,5
CSC (cmol/l)	14,8	10-100	23,7	17,4

Moreover one additional characteristic of compost is the capacity to slowly release nutrients to the soil; they are therefore made available to plants gradually, extending positive effects through the years (Mylavarapu and Zinati, 2009). That is particularly important for nitrogen because in this way losses due to leaching are reduced (around 10% of such element can be considered ready-to-use, 30% is available afterwards during crop development and the remaining part provides a residual effect during time).

As previously described, the pot trials set up in the frame of Action 4 aimed to:

- verify the suitability of selected composts in mixture with other materials as growing medium;
- assess the performance of soil amended with composts and other materials on biomass production of cress used as indicator;
- suggest alternative cultivation practices that could possibly reduce the use of peat in pots cultivation.

On the base of the results obtained, field trials will be set up at Cersaa's premises with different plant species (basil, aromatic plants, lettuce, cabbage) in the frame of Action 6 in order to test the agricultural practices assessed with pot trials and verify in fields and greenhouse cultivation the agronomic performance deriving from a combination of selected composts and zeolite.

4. Trials carried out in the frame of Action 4

Materials and methods

30 kinds of solid and liquid wastes were collected and fully analysed in order to evaluate their potential for agricultural applications. With specific regards to compost, 13 kinds of composts of different origin, composition and stage of maturity were analysed. Chemical parameters considered were the following: TOC, EC, pH, Total N, Total P, Total K, Total Ca, Total Mg, Exchangeable K, Exchangeable Ca, Exchangeable Mg, Chlorides, Sulphates, Nitrates, Ammonium, Boron, Total Fe, Total Ni, Total Cr, Total Mn, Total Zn, Total Cu, Total Mo, Available Fe, Available Ni, Available Cr, Available Mn, Available Zn, Available Cu, Available Mo. Official methods preliminary validated were used (i.e. laws and rules in force in Italy and in the European Union and/or ISO and UNI protocols and/or international methods such as EPA). Results of chemical analysis were compared to the maximum admitted values according to the Italian laws which apply to composts (Legislative Decree n° 75/2010 "Reorganization and revision of regulations on fertilizers, in accordance with Article 13 of Law 7 July 2009, n. 88"; Legislative Decree 217/2006 and its update Ministerial Decree 22/01/2009). Composts that showed values of concern, i.e. higher than the thresholds established by the law with regards to the parameters analysed, were not considered suitable. The others underwent the

following tests in order to better define potential phytotoxicity and agronomic performance according to the guidelines UNI 10780 defined by the Italian legislation (AA.VV., 1998):

- Germination test: it is based on the assessment of the capacity of cress seeds to germinate when put in contact with a aqueous extract of compost. Data assessed after 24, 48 and 72 hours are referred to seeds of the same species put in contact with water (control). The formula used to calculate the germination index (%) is based on the number of germinated seeds and the relevant length of the radicle (Zucconi and De Bertoldi, 1987);
- Growth test: the growth of cress was assessed in a substrate with increasing ratios of compost and peat (20-40-100 %) and put in comparison with a control (peat). Trials were performed in phytotrons (T: 25°C; RH: 75-80 %; light: 12 h/day) and data assessed three times. After 21 days from sowing the development of plants is measured as dry weight;
- Rooting test: it is used to assess the agronomic properties of compost on a pre-applicative scale. Mixtures with increasing ratios of compost and peat (20-40-60-80-100 %) were used. Trials were performed in phytotrons (T: 25°C; RH: 75-80 %; light: 12 h/day). As indicator, lettuce plants were used. Overall vigour of plants, yellowings and root development were assessed using appropriate indexes.

On the base of such tests two composts were selected: one belonging to the category "Ammendante compostato misto" (English non official translation "Mixed composted soil improver") and one belonging to the category "Ammendante compostato verde" (English non official translation "Plant composted soil improver"). Both composts were among the ones provided by Centro Sperimentale di Compostaggio - Ente Parco Nazionale Del Cilento E Vallo Di Diano, Laurino (Salerno), coordinating beneficiary of the LIFE project "Tirsav plus" (www.tirsavplus.eu). Chemical and physical properties of both composts are given in Annex 1.

At the same time 19 different soils collected in different agricultural areas (Italy and Greece) were analyzed according to the following parameters: texture, EC, pH, Total N, Available P, Organic matter, Total limestone, Active limestone, CSC, Exchangeable K, Exchangeable Ca, Exchangeable Mg, Chlorides, Sulphates, Phosphates, Nitrates, Boron, Total Fe, Total Ni, Total Cr, Total Mn, Total Zn, Available Fe, Available Ni, Available Cr, Available Mn, Available Zn (around 500 analysis were carried out on soil samples). Results of chemical analysis were compared to the maximum admitted values according to the Italian laws which apply to soils (Legislative Decree n° 152/2006 - Supplement n° 96 of 14 April 2006, Official Gazette n° 88). On the basis of the results obtained two soils were selected for pot trials: Soil 1 collected at Cersaa's premises and Soil 2 collected in an orchard located in the Savona province (for characteristics see Table 5).

The selected composts were mixed at two rates (20 and 60 % v/v) with soils; two rates of zeolite (2 and 4 % w/w) were added together with slow release fertilizer (dose 2 g/L of substrate). As control peat based substrates normally used for the cultivation of potted plants were adopted. Biomass of cress was assessed through 3 different surveys during a time span of 1,5 months. Data collected were statistically analysed through t-test (confidence interval 95%) and one-way ANOVA to test the effect of treatments on biomass production. Tukey's HSD test was applied when ANOVA revealed significant differences ($P < 0.05$).

An overview of pot trials is given in Table 4.

Table 4 – Details of pot trials.

Cress sowing date	14 january 2013
Watering	$\cong 100 \div 200\ ml_{H_2O}$/pot x day
Selected wastes: Composts from LIFE Project Tirsav plus	• Mix rate with soil [v/v]: 20 and 60% • Typologies of composts tested: Mixed Composted Soil Improver Plant Composted Soil Improver
Fertilizer	OSMOCOTE EXACT - 16:9:12 + 2MgO Controlled release fertilizer (2-4 months); Dose: 2 kg/m3
Zeolite (Clinoptilolite)	IPUS Agro – Austria Rate: 2% w/w or 4% w/w
Soil 1 properties (Cersaa)	Silt loam pH 5 – EC: 93 microS/cm High content of P, Mg and organic matter Good level of N, K, Ca Medium content of limestone
Soil 2 properties (Olive orchard Savona province)	Silt loam pH 8 – EC: 160 microS/cm High content of P and Mg Good level of N, K, Ca, organic matter

<u>*Summary of results*</u>

Main compost properties measured as soon as composts were received at Cersaa's premises (Annex 1) are in compliance with the values foreseen by the law and to the reference values given in Table 2. Regarding organic carbon and humidity they show values higher than the reference ones. The build-up of humidity content in the compost biomass is related to the packaging (big bag) and transportation but it tends anyway to decrease once the bag is open and the compost is used in the trials.

Soil 1 amended with both kinds of composts determined a biomass production comparable to the one obtained from the peat based substrate that was normally characterized by the highest biomass production especially when added with fertilizer and zeolite (at both tested doses). Such effect was observed in all three surveys carried out. With regards to the dose of compost used, a greater biomass was recorded when the lower dose was applied (20% v/v) even though such increase was statistically significant only for the first survey. In any case the higher rate of compost (60% v/v), especially when not combined with the application of fertilizer and/or zeolite, was associated with a lower production of biomass.

The addition of fertilizer determined always an increase of biomass irrespective of the treatments considered.

The addition of zeolite determined a significant increase of biomass with regards to the second and the third survey irrespective of the dose used (2 or 4% w/w).

The deepening of symptoms of damping-off on young cress plants – carried out through biomolecular assays – revealed the presence of *Pythium ultimum*. Such oomycete is a ubiquitous soilborne pathogen which causes damping-off and root rot. It is widely distributed throughout the world and has a wide range of hosts including many important crops. Moderate infections can cause plants wilt, reduce plant populations, and retard maturation. Severe infections often lead to plants collapse and dead. The presence of cress seedlings showing symptoms of damping-off was significantly higher in the treatments where soil 2 (see Table 5) was used (no symptoms at all were detected in the control).

<u>Discussion</u>

According to the trials carried out it is possible to conclude that the mixture of natural soils and compost (ACV or ACM) can lead to a production of biomass – at least regarding the plant species used as indicator in the present trials - comparable to the one obtained with a peat based compost. Moreover, the addition of fertilizer and zeolite to soil can further improve the production of biomass till levels that are even higher than the control from a statistical point of view. The rate of compost used in mixture with soil proved to be a key factor: better results in terms of biomass produced were obtained when lower doses (up to 20% vol/vol) were applied, while the higher dose proved to be not suitable for pot cultivation especially when applied alone without the addition of fertilizer and/or zeolite. The addition of zeolite can be taken in consideration in order to mitigate the negative effect on biomass production deriving from the application of higher doses of compost and, more in general, it always promoted the production of biomass despite the rate applied (2 or 4% w/w) especially when combined with fertilizer. Subsequently the similar behaviour of both composts in mixture with soils can be related to their good overall quality of the products proved by their conformity to the reference values given by the law and assessed through preliminary and targeted analysis and tests. Such tests allowed rejecting composts, and more in general other wastes that were tested for their suitability to be used as substrates for the cultivation of different plant species due to the presence of hazardous level of chemical compounds (e.g. heavy metals) or to the expression of clear signs of phytotoxicity on cress. In any case composts cannot be used alone as growing media but they need to be mixed with another substrates (soil or other materials) at rates varying from 20 till 50% according to the kind and quality of compost in order to give the best results in terms of agronomic performances.

Although no dedicated trials were carried out in order to assess the suppressiveness of soil 1 where significantly lower incidence of damping-off was registered, the data confirmed the potential of soil collected at Cersaa to suppress the development of soilborne pathogens according to previous studies (Garibaldi et al., 1993). Besides the capacity of some composts to suppress soil-borne pathogens in various cropping systems and with different degree of effectiveness is well known (Noble & Coventry 2005; Termorshuizen et al. 2006). Such activity can be further enhanced through the enrichment of compost with natural antagonistic fungi or other microorganisms (Pugliese et al., 2011; Postma et al., 2003).

As previously mentioned, pot trials performed in Action 4 allowed to collect data for the set up of the field trials foreseen in Action 6 of Wastereuse project and that will take place in 2013 and 2014. The trials will be carried out using:

- ACV Compost: basically both composts showed similar agronomic performances, but it is foreseen that ACV will allow a better management of potted cultivation as clearly demonstrated by literature;
- Zeolite: it will be used at the dose of 3% (w/w);
- Fertilizer: slow release fertilizer will be added at a rate of 2 g/L of substrate for cultivations in pots and in benches according to the common practice.

Trials will be set up in open field (lettuce, cabbage and aromatic plants) on a total surface of 500 m^2 and in greenhouse (basil and aromatic plants) in pots (1 liter volume) and on benches (3-4 benches of 30 m^2 each).

5. General guidelines for the use of compost as cultivation substrate

According to the trials performed in the project and to the general remarks given in the introductive section it is possible to propose general guidelines which refer to the use of compost for the cultivation of different plant species with specific regards to potted plants.

1. *Typology of suitable wastes and composts*

Different typologies of wastes can be valorised and therefore used to produce compost to be used for such purpose: crops and pruning remains, residues of plant parts, by-products deriving from food processing, urban wastes,… There are also many different kind of left over materials with chemical and physical properties that can improve the characteristics of composts appropriate as growing media for pot cultivation and nurseries. Such wastes can contribute to the production of mixed composts able to provide substrate properties not originally present and which are useful especially for the cultivation of high-income crop species. Wastes such as residues deriving from hazelnut processing, left over material deriving from wool and mattress manufacturing, wastes driving from oil industry have suitable characteristics to be used for compost production, improving drainage or, in other case, when necessary, favouring water retention. (Gonzalez and Cooperband, 2002).

Wastes/by products that can be used for the cultivation of ornamental potted plants assuring a good draining capacity and avoiding slump are e.g. the following: hazelnut shells and perisperm, olive stones, coconut perisperm, latex deriving from mattress manufacturing). They have low EC value and pH close to neutrality, so they are not likely to increase the content in soluble salts and they do not affect substrate pH. ACV and ACM composts showed to be the most suitable ones for pot cultivation with results comparable, and sometimes better, with regards to a peat based substrate in terms of biomass production (e.g. sage and basil) when mixed at doses ranging between 20 and 40% (v/v) with organic by-products (fruit shells and stones, perisperm), perlite and peat (Minuto et al., 2006).

2. Quality assessment

In order to assess the quality and the agronomic properties of compost it is fundamental to perform preliminary tests and to verify potential phytotoxic effects using selected plants as indicators. The following parameters and tests should always be assessed:

a. Relative Humidity
b. Total humidity
c. Residual humidity (calculated on an air dried sample)
d. Volatile substances and ashes
e. Electrical conductivity
f. pH
g. Total Organic Carbon
h. Total humus
i. Humic and fulvic acids
j. Nitrogen:
    i. Total
    ii. NO_3^-
    iii. NO_2^-
    iv. NH_4^+
k. Glass (incineration and hydrogen peroxide method) and plastic content (granulometric fractions)
l. Real density
m. Germination index
n. Growing index
o. Rooting test

p. Cultivation test

3. *Mixing rates and doses*

Composts can barely be used alone, while when mixed at specific rates with peat or other materials they show interesting properties. Such aspect is crucial since it allows to reduce the overall amount of peat used and, more in general, the reliance on this material strictly related to the heavy exploitation of bogs. Mixing of composts can be adopted especially for the cultivation of potted plants as long as they are mixed at the rates above mentioned with peat. When adopting compost-based growing media it should be kept in mind that they can reduce root development in the first cultivation phases especially for potted plants due to the significant content in highly soluble mineral salts (see Table 2 regarding the EC values for ACM and ACV), but they can afterwards promote plant growing – even more than when just peat is used - when nutrient request increases and normal watering is applied favouring the dilution of nutrients and avoiding potential phytotoxic effects.

When compost is used in open field cultivation as soil improver, it can represent an alternative to manure for cereals and fodder, vegetables, fruit crops (Martìnez-Blanco et al., 2011).

a. *Recommended application rates of compost for cultivation of potted plants* (Centemero, 2009)

The following parameters should be carefully considered when mixing compost with growing media:

- Plant species (herbaceous, tree, bush,…);
- Cultivation stage considered (sowing, transplant,…);
- Duration of the cultivation cycle;
- Pot dimension;
- Physical and chemical properties of compost;
- Physical and chemical properties of the materials used in mixture with compost (peat and inorganic inactive materials such as pomix, perlite,…);
- Cultivation technique adopted;

In consideration of the following: a. increasing doses of ACV or ACM in the mixtures determine an increase of macroelements and, consequently, of the EC (salinity) of the growing medium; b. 2 dS/m can be considered a safe threshold for EC,

it is possible to conclude that ACM can be used till a maximum of 20% (vol/vol) while ACV till a maximum of 40% (v/v).

b. *Recommended doses of compost for application in open field*

Table 5 summarizes the nutrient balance deriving from the application of compost (ACV and ACM typologies) in doses suitable for crop cultivation in open field (AA.VV., 2010).

Table 6 – Annual supply of nutrients and lime with compost doses suitable for crop cultivation (Modified from AA.VV., 2010).

Annual supplies	**Compost doses (t/ha dry matter) 3 years**		**Assessment**
	20 - medium	30 - high	
Nutrients in kg/ha	Medium ranges		Average nutrient balance
Nitrogen - N	80-110	120-160	Medium dose: slightly negative High dose: balanced-slightly positive
Phosphorous – P_2O_5	35-55	60-80	Mainly balanced
Potassium – K_2O	60-85	100-120	For average removals: positive For high removals: slightly negative to balanced
Magnesium - MgO	35-60	60-85	Always highly positive
Lime - CaO	2,0-4,0	3,0-5,5	Positive

4. General hints about composting

When composting the following factors should be carefully considered (Bertoldi et al., 1996):

a. Do not mix only wastes with high water content;

b. Do not wait till the end of the composting process to sort and separate plastic or glass pieces;

c. Crumble wastes into pieces of medium size (≤ 2 cm per axe considering a roughly egg-shape);

d. Do not accumulate wastes and wait for too long before starting composting;

e. Compost pile should be around 2-2,5 m high;

f. Do not press the pile with mechanical tools or equipments;

g. The pile must be turned upside down on a regular basis;

h. The pile must be poured with water in order to maintain a proper humidity;

i. Temperature of the pile should be checked through probes during the composting period. It should be around 45-50 °C in the central part of the pile and 25-30 °C on the surface of pile;

j. Agronomic tests should be carried out in addition to traditional physical/chemical analysis in order to define the overall quality of compost (see point 2 – Quality assessment).

5. *Storage of compost*

It is a key phase that has great influence on the final quality of the product. The following factors should be taken in consideration when handling compost:

a. Evolution of temperatures in the last two weeks before use (see letter "I" point 5);

b. Final humidity percentage in the compost stack should be < 80%, optimal around 60%;

c. Compost must be stored under covering so that it is not exposed to meteorological events;

d. Compost should be sold and distributed after proper packing in sacks that can preserve its properties during time.

6. Exploitation and enhancement of the potential suppressive properties of compost

Some composts show interesting suppressive properties, i.e. they can limit infestation by certain soilborne pathogens (Postma et al., 2003). Such characteristics need to be investigated regarding the different kinds of compost and, within the same typology, for each batch considered. The addition of specific biological control agents (i.e. *Trichoderma viride* and *T. harzianum*) to compost can lead to obtain a substrate with a broader suppressive effect. The selection of biological agents from suppressive composts might also be a good strategy in order to increase the disease suppressiveness of compost (Pugliese et al., 2008). Furthermore, the inoculation of biological agents soon after the peak heating could reduce the quantities of microorganisms necessary to fortify the composts (Scheurell and Mahaffee, 2005). Finally the combined effect of soils that showed promising suppressive properties together and enriched composts could be also investigated in order to take full advantage of the substrate for the control of soilborne pathogens.

6. Conclusions

An extensive survey carried out on around 30 wastes based on chemical analysis and laboratory assays allowed the selection of two kinds of composts with promising agronomic properties that were further investigated through pot trials using cress as indicator plant. The suitability of such composts as growing media when mixed with natural soils and other inorganic materials (zeolite) was put in comparison with a peat based substrate traditionally used for pot cultivation. Rates of compost (ACV or ACM) variable from 20 to 40% (v/v) mixed with natural soil characterized by a medium/high content in macroelements, Ca and Mg can lead to a production of biomass – at least regarding the plant species used as indicator in the present trials - comparable to the one obtained with a peat based compost. The addition of fertilizer and zeolite to soil can further improve the production of biomass and mitigate the negative effect on biomass production deriving from the application of higher rates of compost.

Field and greenhouse trials will be set up at Cersaa's premises with different plant species in order to test the agricultural practices assessed with pot trials and verify the agronomic performance deriving from a combination of selected composts and zeolite.

According to the results obtained and to a bibliographic search, general guidelines which refer to the use of compost for the cultivation of different plant species with specific regards to potted plants are given.

When compost is adopted in nurseries or for the cultivation of ornamentals, the assessment of its chemical and physical parameters (according to the indications given by the law) as well as its main agronomic properties is crucial. Among the latter, recording of indexes regarding growing, rooting and development of plants can help in defining compost properties. It is finally important to stress that the good properties of compost and, at the end, the related agronomic performances depend mainly on the starting materials used, on the rate of maturation reached, on the composting process adopted and on the care posed in storing of the final product. Moreover the assessment of potential suppressive properties of compost can represent an opportunity for a sustainable control of certain soilborne pathogens.

From a general point of view, the possibility to use compost as a key component of growing media is established since many years since it can lead not only to a general improvement of the substrates used for the cultivation of potted plants but, more in general, it can contribute to the overall environmental sustainability of the sector of growing media limiting the exploitation of peat bogs and the costs – both economic and environmental - related to the transportation of such fossil resource from the countries of production to the areas where it is used.

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Annex 1 – Chemical analysis of the composts used in the trials

a. Plant composted soil improver

Laboratorio Chimico Merceologico

Azienda Speciale per la Formazione Professionale e la Promozione Tecnologica e Commerciale

Regione Rollo, 98 - 17031 Albenga (Savona) - Tel. e Fax 0182 50960

Rapporto di Prova N. 2682\2012

Albenga 15/06/2012

Committente: Az.Speciale Laboratorio Chimico CCIAA Savona
Via Quarda Superiore, 16 17100 Savona (SV)

Numero campione: 2.682 **Data ricevimento:** 26/03/12 **Data inizio prove:** 26/03/12 **Data termine prove:** 15/06/12

Categoria Merceologica: MATERIALI
Prodotto dichiarato: Materiale
Descrizione Campione: Progetto Life Waste reuse: compost codice W - UTR220711 BOUT-R
Etichetta Campione:
Descrizione Sigillo:
Quantità Campione: 1 **Restituzione Campione:** No
Imballaggio: Contenitore in plastica
Campionamento: Effettuato dal cliente

Il presente rapporto riguarda esclusivamente il campione sottoposto a prova ed esso non può essere riprodotto parzialmente, se non previa approvazione scritta da parte di questo Laboratorio.
Il Laboratorio conserva i campioni per un massimo di 30 (trenta) giorni dalla data di emissione del rapporto di prova salvo diverse disposizioni di legge, accordi specifici con il cliente, specifica instabilità dei campioni (in questo caso i tempi possono essere modificati previa comunicazione al cliente).

Data	Nome Prova	Metodo analitico	Valore	Annotazione
26/03/2012	Carbonio organico	*Regione Piemonte Metodi di analisi dei compost 1998 Met C 6.2.*	48,1 % p/p su s.s.	
26/03/2012	Conducibilità	*UNI EN 13038:2002*	1.187 microS/cm	
05/04/2012	pH	*UNI 13037 2002*	7,33 Unità di pH	
26/03/2012	Azoto totale	*Reg CE 2003/2003 Metodo 2.3*	11,9 g/Kg	
26/03/2012	Fosforo totale (P2O5)	*Reg CE 2003/2003 Metodo 3.1.1*	2,6 g/Kg	
05/04/2012	Potassio (come K2O)	*Reg CE 2003/2003 Metodo 4.1*	8,4 g/Kg	
26/03/2012	Calcio totale	*UNI 10780:1998 App B*	0,37 % p/p su s.s.	
26/03/2012	Magnesio totale	*UNI 10780:1998 App B*	0,23 % p/p su s.s.	
26/03/2012	Cloruri idrosolubili	*DM 13/09/1999 GU n° 248 21/10/1999 Met IV.2*	1.107 mg/Kg	
26/03/2012	Solfati	*MI_29/08/T rev 1 2008*	97 g/Kg	
26/03/2012	Nitrati	*MI_29/08/T rev 1 2008*	452 g/Kg	
05/04/2012	Azoto ammoniacale (come N)	*Reg CE 2003/2003 Metodo 2.1*	0,1 %	
26/03/2012	Ferro	*Metodi di Analisi per i Fertilizzanti - Met. IX.24 (2006)*	3.925 mg/Kg	
26/03/2012	Nichel	*UNI 10780:1998 App B*	NR(< 10 mg/Kg s.s.)	
26/03/2012	Cromo totale	*UNI EN 13650:2002*	0 mg/Kg	
26/03/2012	Manganese	*Metodi di Analisi per i Fertilizzanti - Met. IX.24 (2006)*	122 mg/Kg	
26/03/2012	Zinco totale	*UNI 10780:1998 App B*	32 mg/Kg s.s.	
26/03/2012	Rame totale	*UNI 10780:1998 App B*	18 mg/Kg s.s.	
26/03/2012	Ferro assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	24 mg/Kg	
26/03/2012	Nichel assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	NR(< 1 mg/Kg)	
26/03/2012	Cromo assimilabile	*DM 13/09/1999 GU n° 248 21/10/1999 Met XI.1*	NR(< 0,1 mg/Kg)	
26/03/2012	Manganese assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	34,1 mg/Kg	
26/03/2012	Zinco assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	3,1 mg/Kg	
26/03/2012	Rame assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	1,0 mg/Kg	

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IL DIRETTORE DEL LABORATORIO
DOTT. LUCA MEDINI

Laboratorio Chimico Merceologico

Autorizzazioni e riconoscimenti

- Certificato da Certiquality (n° 974) per la conformità del sistema di gestione qualità ai sensi della norma UNI EN ISO 9001:2008
- Autorizzazione da parte del Ministero delle Politiche Agricole ad eseguire per l'intero territorio nazionale analisi ufficiali nel settore oleicolo e vitivinicolo e certificati di analisi per la esportazione dei vini, compresi i Paesi ove è previsto il marchio INE
- Iscritto all'elenco della Regione Liguria dei laboratori che effettuano analisi ai fini dell'autocontrollo per le industrie alimentari

b. Mixed composted soil improver

Laboratorio Chimico Merceologico

Azienda Speciale per la Formazione Professionale e la Promozione Tecnologica e Commerciale

Regione Rollo, 98 - 17031 Albenga (Savona) - Tel. e Fax 0182 50960

Rete dei Laboratori delle Camere di Commercio

Rapporto di Prova N. 2677\2012

Albenga 15/06/2012

Committente: Az.Speciale Laboratorio Chimico CCIAA Savona
Via Quarda Superiore, 16 17100 Savona (SV)

Numero campione: 2.677 **Data ricevimento:** 26/03/12 **Data inizio prove:** 26/03/12 **Data termine prove:** 15/06/12
Categoria Merceologica: MATERIALI
Prodotto dichiarato: Materiale
Descrizione Campione: Progetto Life Waste reuse: compost codice S - NAT150411
Etichetta Campione:
Descrizione Sigillo:
Quantità Campione: 1 **Restituzione Campione:** No
Imballaggio: Contenitore in plastica
Campionamento: Effettuato dal cliente

Il presente rapporto riguarda esclusivamente il campione sottoposto a prova ed esso non può essere riprodotto parzialmente, se non previa approvazione scritta da parte di questo Laboratorio.
Il Laboratorio conserva i campioni per un massimo di 30 (trenta) giorni dalla data di emissione del rapporto di prova salvo diverse disposizioni di legge, accordi specifici con il cliente, specifica instabilità dei campioni (in questo caso i tempi possono essere modificati previa comunicazione al cliente).

Data	Nome Prova	Metodo analitico	Valore	Annotazione
26/03/2012	Carbonio organico	*Regione Piemonte Metodi di analisi dei compost 1998 Met C 6.2.*	44,0 % p/p su s.s.	
26/03/2012	Conducibilità	*UNI EN 13038:2002*	2.130 microS/cm	
05/04/2012	pH	*UNI 13037 2002*	8,48 Unità di pH	
26/03/2012	Azoto totale	*Reg CE 2003/2003 Metodo 2.3*	24,0 g/Kg	
26/03/2012	Fosforo totale (P2O5)	*Reg CE 2003/2003 Metodo 3.1.1*	3,3 g/Kg	
05/04/2012	Potassio (come K2O)	*Reg CE 2003/2003 Metodo 4.1*	13,4 g/Kg	
26/03/2012	Calcio totale	*UNI 10780:1998 App B*	0,60 % p/p su s.s.	
26/03/2012	Magnesio totale	*UNI 10780:1998 App B*	0,29 % p/p su s.s.	
26/03/2012	Cloruri idrosolubili	*DM 13/09/1999 GU n° 248 21/10/1999 Met IV.2*	1.445 mg/Kg	
26/03/2012	Solfati	*MI_29/08/T rev 1 2008*	364 g/Kg	
26/03/2012	Nitrati	*MI_29/08/T rev 1 2008*	207 g/Kg	
05/04/2012	Azoto ammoniacale (come N)	*Reg CE 2003/2003 Metodo 2.1*	0,3 %	
26/03/2012	Ferro	*Metodi di Analisi per i Fertilizzanti - Met. IX.24 (2006)*	3.197 mg/Kg	
26/03/2012	Nichel	*UNI 10780:1998 App B*	NR(< 10 mg/Kg s.s.)	
26/03/2012	Cromo totale	*UNI EN 13650:2002*	0 mg/Kg	
26/03/2012	Manganese	*Metodi di Analisi per i Fertilizzanti - Met. IX.24 (2006)*	139 mg/Kg	
26/03/2012	Zinco totale	*UNI 10780:1998 App B*	65 mg/Kg s.s.	
26/03/2012	Rame totale	*UNI 10780:1998 App B*	22 mg/Kg s.s.	
26/03/2012	Ferro assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	40 mg/Kg	
26/03/2012	Nichel assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	NR(< 1 mg/Kg)	
26/03/2012	Cromo assimilabile	*DM 13/09/1999 GU n° 248 21/10/1999 Met XI.1*	NR(< 0,1 mg/Kg)	
26/03/2012	Manganese assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	12,9 mg/Kg	
26/03/2012	Zinco assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	8,8 mg/Kg	
26/03/2012	Rame assimilabile	*DM 13/9/1999 GU n° 248 21/10/1999 Met XII.1*	0,6 mg/Kg	

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