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Roberto BARBUTI, Stefano CHESSA, Roberto FRESCO, Paolo MILAZZO

PREFACE

The technological innovation in biology and agriculture often leveraging on innovation in computer science and engineering, pushed forward the process of integration among these disciplines. In particular, information technology (IT) provides common methodologies and tools for the automatic acquisition and analysis of the data that concern the management and optimization of the natural and territorial resources.

In agriculture, applications of IT enable the integration of interventions concerning its sustainability and productivity, by offering methods and tools to monitor, control, analyse and optimize the production while keeping it respectful of the environment. Similarly, the best practices for bio sustainability, for the management of bio-diversity and for the bioremediation of the environment (including soil, water etc…) are also progressively adopting IT, which enable more focused (and thus more effective) applications.

In this context, the conference “Technologies and innovation for sustainable management of Agriculture, Environment and Biodiversity” (TI4AAB), was held in July 2016 at the Natural History Museum of the University of Pisa located in the Calci Charterhouse (Calci, province of Pisa) in order to encourage the sharing of emerging knowledge about the above topics.

In fact, the conference was dedicated to fostering innovative cross-disciplinary research and applications and to stimulating the exchange of strategies and experiences, among academic and company experts from different disciplines (agriculture, biology, computer science and engineering and environmental decision making), in order to encourage a common, interdisciplinary discussion about the adoption and perspectives of IT in modern agriculture, environmental management, biodiversity and bio-sustainability in general.

The conference was held under the auspices of the municipality of Calci, the University of Pisa and of the “Ordine dei Dottori Agronomi e Dottori Forestali”. It was also attended and supported by some leading national and worlwide industries, like CAEN RFID, OSRAM, STMicroelectronics, EBV Elektronik, Qprel Srl, AEDIT Srl, EMipiace Srl, and Zefiro Ricerca & Innovazione Srl, and by the Italian National Forestry Authority.

This volume constitutes a selection of the contributions presented at the conference and cover the aspects of innovation in agriculture, biology, and applied information technology. In particular, concerning innovation in agriculture, the paper by Nin et al. studies new soilless cultivation systems for wild strawberry growing in the Tuscan Appennine mountains. The paper by Prisa describes experimental research concerning the use of zeolites in combination with effective microorganisms, in order to improve the quality of olive trees. Finally, the paper by Lombardo et al. describes collaborative approaches to innovation in agriculture (co-generation of technology).

Concerning innovation in biology, the paper by Baldacci et al. describes the results of the preliminary phases of the AIS-LIFE project, which aims at developing aerobiological information systems in order to improve pollen-related allergic respiratory disease management. Still concerning the AIS-LIFE project, the paper by Natali et al. aims to describe the strategy used in AIS-LIFE project, to evaluate daily pollen concentration in the atmosphere produced by many allergic plant species. The use of data and GIS system are shown as an approach to assess allergy risk maps.

Concerning innovation in computer science applied to agriculture and biology, two contributions focus on modeling approaches, and two contributions provide a survey of information technology applied to agriculture and biology. Specifically, the paper by Bodei et al. describes the application of the IOT-LYSA formal modelling framework to a possible scenario of grape cultivation, in order to assess water consumption, and the paper by Barbuti et al. proposes a mathematical model of artificial reefs, in order to study the dynamics of algal coverage and of populations of fish in some Italian artificial reefs. Finally, the paper by Fresco et. al. explores the current challenges and IT solutions in order to realize a digital agriculture framework, intended as an evolution from Precision Farming to connected knowledge-based farm production systems, and the paper by Pucci et al. provides a survey on biologging methodologies for the collection of knowledge about animals' behaviour, making a review of some related common data analysis techniques.

All papers have been carefully reviewed by experts in the specific fields. Here is the list of the reviewers, that we thank for the collaboration.

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Domenico PRISA [*]

ITALIAN CHABAZITIC-ZEOLITITE AND EFFECTIVE MICROORGANISMS FOR THE QUALITATIVE IMPROVEMENT OF OLIVE TREES

Abstract: D. Prisa, *Italian chabazitic-zeolitite and Effective Microorganisms for the qualitative improvement of olive trees.*

Natural Zeolites are a mineral family composed by 54 different species chemically defined as "hydrated allumino-silicates of alkaline and alkaline earth elements" and structurally belonging to the tectosilicates. Due to their crystal chemistry, zeolites show physical-chemical peculiarities such as high and selective cation exchange capacity (CEC), reversible dehydration, selective molecular absorption, and catalytic behaviour. Therefore, rocks containing more than 50% of zeolites (zeolitites) are widely and profitably utilized in the purification of municipal, zootechnical and industrial wastewaters, as additive in animal nutrition, agriculture and floriculture.

Moreover, concerning microorganisms, Effective microorganisms (EM) comprises of live cultures of microorganisms isolated from fertile soils in nature that are useful during crop production. EM has been found to increase seed germination, vigour, early fruiting and the number of fruits in different species. In this paper we describe a test carried out at the experimental greenhouses of Crea-Viv, was evaluated the possibility of using the zeolitite and EM mixed to the substrate, for to increase the olive plants quality. The test showed a larger percentage of rooting of cuttings placed in zeolitite and EM, compared to those in pumice-stone, with a level of root growth significantly increased. These data highlight some of the positive effects that the zeolitite and symbiotic microorganisms, might make once used in the rooting of cuttings of olive trees, but also in growth substrates.

Keywords: zeolite; zeolitite; EM technology; corroborant; olive plants

Riassunto: D. Prisa, *Zeolitite-chabasite italiana e microrganismi effettivi per il miglioramento qualitativo degli alberi di olivo.*

Le Zeoliti naturali sono una famiglia di minerali composta da 54 specie chimicamente definibili come silicati alluminici idratati di terreni alcalini e strutturalmente appartenenti ai tectosilicati. Per la loro chimica cristallina, le zeolititi si caratterizzano per proprieta' fisico-chimiche come l'alta selettività e capacità di scambio cationico (CSC), disidratazione reversibile, assorbimento molecolare selettivo e comportamento catalitico. Pertanto, rocce contenenti più del 50% delle zeoliti (zeolititi) sono ampiamente e proficuamente utilizzati nella purificazione di acque di scarico urbane, o per usi zootecnici ed industriali, come additivo per mangimi per gli animali, in agricoltura e in floricoltura.

In relazione alla classe di microorgarnismi, i microorganismi effettivi (EM) comprendono delle colture vive di microrganismi isolati da terreni fertili che possono essere utilizzati nella produzione di colture. Gli EM sono stati usati per aumentare la germinazione dei semi, la vigoria, precocita' di fruttificazione e il numero di frutti prodotti in diverse specie. Nelle prove effettuate presso le serre sperimentali del Crea-Viv, è stata valutata la possibilità di utilizzare la zeolitite e i microorganismi EM miscelati al substrato, al fine di aumentare la qualità delle piante di olivo. Il test ha dimostrato una maggiore percentuale di radicazione delle talee di olivo nella miscela zeolitite e EM, rispetto a quelle torba e pomice. Si sono riscontrati livelli di crescita delle radici significativamente aumentati. Questi dati evidenziano alcuni degli effetti positivi che la zeolitite e i microrganismi simbionti, possono produrre quando sono utilizzati per la radicazione delle talee degli olivi, ma anche per ottenere effetti benefici nei substrati di crescita.

Parole chiave: zeolite; zeolitite; tecnologia EM; corroborante; piante d'olivo.

INTRODUCTION

The olive tree (*Olea europaea L.*), was originally from Asia Minor from where it spread over thousands of years, especially in the Mediterranean basin, establishing itself mainly in the coastal and sub-coastal areas. The olive is a very long-lived plant that can easily reach a few hundred years: this characteristic is due primarily to the fact that is able to regenerate completely or mostly of its apparatus vegetative and root system that are damaged. The olive tree is also an evergreen plant, or its vegetative stage is almost continuous throughout the year, with only a slight decrease in winter.

The alternation of production is one aspect which must be taken into account in olive growing because its effects have an impact on both the price and the quality of the finished product (both oil and table olives). The causes are

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a mix of weather conditions, pests, pruning and fertilizing wrong, excessive delay in collecting the fruit, and not least the preparation of the same cultivar. To obviate this event, the following measures should be taken timely and in a continuous manner:

1. maintaining a regular distribution of production on the plant with extraordinary pruning (cutting ring);
2. repeated practices of irrigation and fertilization throughout the year;
3. carrying out a regular pest control, especially against the olive fly anticipating as much as possible the timing of harvest.

For multiplication typically they are used wild olive trees or olive from rustic and vigorous cultivars. The latter has a large inhomogeneity of development, more pronounced in the olive by the fact that many varieties are self-sterile. Normally is preferred to perform the cuttings of these plants, to obtain a large number of individuals who all have the same qualitative and quantitative characteristics. The rooting substrates used for these plants, are generally constituted by mixtures of peat and pumice or vermiculite in different percentages, but often fail to meet the needs of farmers, in terms of quality and time for the production of saleable items.

ZEOLITITE

Zeolitite is the scientific name introduced in 2011 (Galli & Passaglia) in substitution of the generic and improper terms currently utilized in literature (natural zeolites, sedimentary zeolites, zeolite-rich rocks, zeolite-rich tuffs) to define diagenized pyroclastic rocks (tuffs, ignimbrites) containing more than 50% of zeolites (normally, chabazite, clinoptilolite, phillipsite, mordenite) and subordinate amounts of other silicates (quartz, feldspar, pyroxene, mica-illite) and amorphous original volcanic glass. Due to both the presence of the zeolites and texture of the rocks, zeolitites exhibit high (130-200 meq/100g) and selective (mainly for NH_4 and K) cation exchange capacity, reversible dehydration, permeability, high water retention, all features useful in agricultural, horticultural and floricultural applications. Accordingly, the zeolitites, itemized by the predominant zeolitic species (chabazitic, cliniptilolitic, etc), have been recently inserted among the "ammendanti" (Decreto del Ministero delle Politiche Agricole e Forestali del 3 Marzo 2015 pubblicato sulla Gazzetta Ufficiale della Repubblica Italiana il 7 Maggio 2015, serie generale n. 104). The zeolitites, were used in this experiment because they exhibit several interesting features for use in agriculture, in horticulture and in particular in tomato (Passaglia *et al.*, 1997), celery (Bazzocchi *et al.*, 1996), courgette and melon (Passaglia *et al.*, 2005b), vegetables and fruit (Passaglia and Poppi, 2005a). The experiment has shown an increase in the total production of the product ended up hectare of land. In floriculture, the use of zeolitites has given instead an increase in height, the total number of inflorescences, buds, flowers, bulbs and the likes of increased earliness of flowering geranium (Passaglia *et al.*,1998; Passaglia *et al.*, 2005b), Lilium, Gerbera, Chrysanthemum, Liatris spicata, Tulip, *Cupressus sempervirens*, Camellia and Leucospermum (Prisa and Burchi, 2015).

EFFECTIVE MICROORGANISMS

Effective microorganisms (EM) technology was first developed in the 1970 (Higa, 2003). EM comprises a mixture of live cultures of microorganisms isolated from fertile soils in nature that are useful during crop production (Mohan, 2008); these may include photosynthetic bacteria (*Rhodopseudomonas palustris, Rhodobacter sphaeroides*), lactobacilli (*Lactobacillus plantarum, L.casei and Streptococcus lactis*), yeasts (*Saccharomyces spp.*), and Actinomycetes (*Streptomyces spp.*; Javaid, 2010). The principle activity of EM is to increase the bio-diversity of soil micropora, thereby increasing crop yield. Photosynthetic bacteria, are reported to work synergistically with other microorganisms to provide the nutritional requirements of the plant and to reduce disease (Condor *et al.*, 2007). Subadiyasa (1997) described EM technology as a technique to support natural farming. EM interacts with the soil-plant ecosystem to suppress plant pathogens and agents of disease, to solubilise minerals, to conserve energy, to maintain soil microbial-ecological balance, to increase photosynthetic efficiency, and fix biological nitrogen (Subadiyasa, 1997).

The aim of this experiment carried out at the CREA-VIV of Pescia (PT) was the creation of innovative mixtures, consisting of minerals of various kinds and symbiotic microorganisms. These microorganisms both alone and together with the peat could: 1) increase the percentage of cuttings rooting; 2) increase the root volume; 3) improve the qualitative development of the olive trees; 4) speed up the cultivation cycle and reduce mortality post-transplant of the cuttings rooted.

MATERIAL AND METHODS

The experiments were carried out at the CREA-VIV of Pescia (PT) on an olive tree cuttings (*Olea europaea L.*) from plants of seven years. The cuttings, after being treated with rooting hormone, have been placed under a polyethylene tunnel. The used cultivars were: Maurino, Frantoio, Moraiolo, Leccio, Pendolino, Leccino.

The experimental thesis of rooting test were:

Control: pumice-stone 100% (unheated) with hormone treatment of cuttings 5-7 "with IBA 2000 ppm;

Treated: pumice-stone 70% + zeolitite (chabazite) 30% (unheated) with hormone treatment of cuttings 5-7 "with IBA 2000 ppm.

Have been around 1000 plants x 3 replicates for each treatment (3000 plants for thesis of the same varieties), in a randomized block experimental design. The measurements carried out at the end of experimentation on the plants, were: rooting percentage, number, length and fresh weight of the roots. The Italian chabazitic-zeolitite utilized in the experiments (particle size 3-6 mm) is characterized by: total zeolitic content 68% ± 2% (65% of chabazite + 3% of phillipsite); cation exchange capacity of 210 ± 3 meq/100g, (140 due to Ca, 60 to K, 6 to Na and 4 to Mg); apparent density 0.70; water retention 40%; percolation speed 2 cm/s.

The experimental thesis of the growth of cultivar test. Leccino were:

Control: 70% peat + 30% pumice-stone + (4 kg m-3 of Osmocote Pro® 5-6 month)

Treated: Peat 70% + chabazitic-zeolitite 30% + EM (radical wetting before potted) + (4 kg m-3 of Osmocote Pro® 5-6 month).

The particle size of chabazitic-zeolitite used was 3-6 mm. Have been around 54 cuttings x 4 replicates for each treatment (216 plants for thesis), in a completely randomized experimental design. The surveys carried out at the end of testing on plants were: plant height, vegetative fresh weight, root fresh weight.

RESULTS

The experiment showed that the chabazitic-zeolitite can improve the rooting of olive cuttings. In fact, treatment by chabazitic-zeolitite and EM, increased the percentage of cuttings rooted in pumice-stone of all the different cvs with respect to the control (tab. 1).

In particular, Maurino and Frantoio species appear to respond better to treatment with zeolite and microorganisms with respectively 60% and 65% of rooted cuttings, compared to 25% and 30% of their control.

Also with regard to the fresh weight of the roots (tab. 2), there was a significant increase in all theses treated by chabazitic-zeolitite and EM.

In particular, the species Moraiolo, Leccino and Leccio were those that showed a radical fresh weight increased with respect to the others. In fact Moraiolo, Leccio and Leccino cuttings respectively showed a radical weight of 7.00g, 6.80g and 6.70g compared with 4.22g, 3.35g and 4.40g of their controls.

The growth test carried out on the cultivar Leccino (tab. 3), showed a significant increase of the plants height (fig. 1), of the vegetative fresh weight and root fresh weight (fig. 1) of the olive trees grown in chabazitic-zeolitite + Em compared with the control in peat and pumice-stone.

Another interesting outcome from the theses treated by zeolitite and microorganisms (fig. 2), has been the length of the roots of the cuttings treated by zeolitite and EM.

Despite their higher fresh weight, they showed a significantly lower length of root hairs compared to the control in pumice-stone.

CONCLUSION

Experiment results revealed a larger percentage of rooting of cuttings placed in zeolitite and EM, compared to those in pumice-stone, with a level of root growth significantly increased. The shorter length of roots grown in

Tab. 1 - Effect of zeolitite and EM microorganisms on the rooting percentage of olive cuttings

Rooting percentage (%)	Maurino	Frantoio	Moraiolo	Leccio	Pendolino	Leccino
Chabazitic-zeolitite 30% + Ema+ pumice-stone 70%	60%	65%	40%	50%	45%	23%
Pumice-stone 100%	25%	30%	35%	30%	20%	6%

Tab. 2 - Effect of zeolitite and EM microorganisms on fresh weight of olive roots

Fresh weight of olive roots (g)	Maurino	Frantoio	Moraiolo	Leccio	Pendolino	Leccino
Chabazitic-zeolitite 30% + Ema+ pumice-stone 70%	5.70 a	6.35 a	7.00 a	6.80 a	5.45 a	6.70 a
Pumice-stone 100%	3.22 b	4.00 b	4.22 b	3.35 b	4.12 b	4.40 b

Tab. 3 - Effect of zeolitite and Em microorganisms on the growth of olive trees cv Leccino

Thesis	Plant height (cm)	Vegetative fresh weight (g)	Root fresh weight (g)
Peat 70% + pumice-stone 30%	22.11 b	45.12 b	32.14 b
Ema + Peat 70% +chabazitic- zeolitite 30%	41.13 a	62.43 a	49.44 a

Fig. 1 - Effect of zeolitite and EM microorganisms on plant growing and rooting of cv. leccino

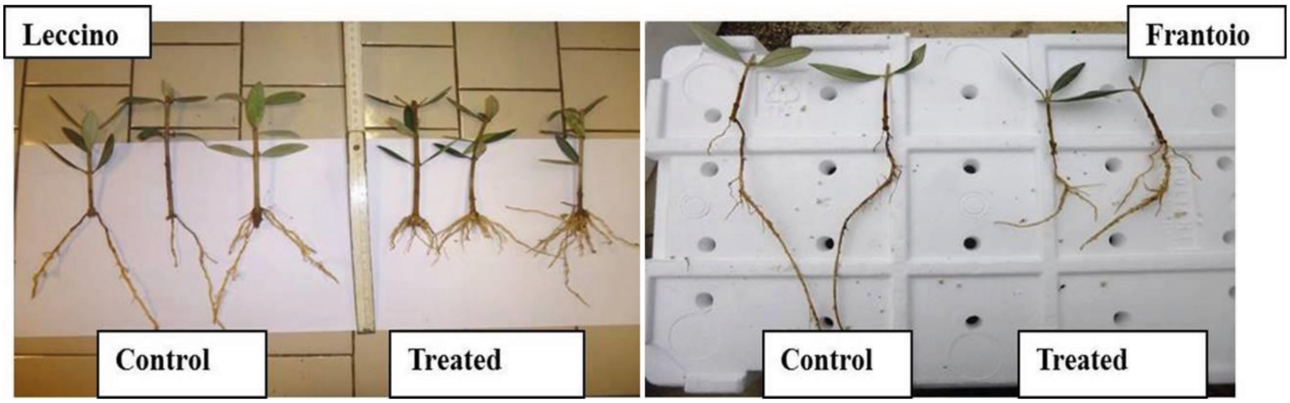

Fig. 2 - Effect of zeolitite and EM microorganisms on rooting of cv. Leccino and Frantoio

zeolitite compared with the control, is an effect probably due to the improvement of water retention in areas where the zeolites grains were concentrated, and stimulated the development of micro-roots. The use of zeolitite in agronomic field, highlighted the following economic and environmental benefits: 1) qualitative and quantitative improvement of production

(Di Giuseppe *et al.*, 2016); 2) reducing the use of fertilizers and manures; 3) reduction of water use for irrigation; 4) reduction of the hydrological system. (Mumpton, 1978, 1984; Barbarick and Pirela, 1984; Ming and Allen, 1995; Chelishchev, 1995; Ming and Allen, 2001; Passaglia and Marchi, 2002).

The results seem to take on greater importance considering the fact that the pallets of rooting, were not heated. Nevertheless, pallets with chabazitic-zeolitite and EM obtained a good percentage of rooting and this is probably due to the fact that this mineral, as well as it releases the water slowly (pumice-stone dries fast), is able to stabilize the temperature of the substrate rooting and allow a better root development due to microbial colonization. Also in the next phase of growth of olive trees the chabazite and Em microorganisms added substrates were the most efficient in stimulating the vegetative and root development (Mohan, 2008; Higa, 2012).

These data highlight some of the positive effects that the zeolitite and symbiotic microorganisms, might produce when used in both the rooting of cuttings of olive trees, and growth substrates. The ease of use of the microorganisms, the remarkable chemical and physical characteristics of the zeolitite as well as the total absence of contraindications, make these natural products good candidates to replace the substrates commonly used in soilless cultivation with the benefit in speeding up the plant growing.

Statistical analysis performed through two-way ANOVA; Different letters within each column and indicate significant differences according to Duncan's multiple-range test.

Statistical analysis performed through two-way ANOVA; Different letters within each column and indicate significant differences, according to Duncan's multiple-range test.

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