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Zeolites as additives for the rooting of Camellia japonica and Proteaceae Juss.

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---***ABSTRACT***---
The term "zeolite" was created by Cronstedt (1756, for mineral which expel water when heated and hence seem to boil. They are very common and well known as fine crystals of hydrothermal genesis in geodes and fissures of eruptive rocks, or as microcrystalline masses of sedimentary origin. A natural zeolite is a framework alumina-silicate whose structure contains channel filled with water and exchangeable cations; ion exchange is possible at low temperature (100°C at most) and water is lost about 250°C and reversibly re-adsorbed at room temperature. In this test carried out at the CREA-OF (Pescia- PT) experimental greenhouses, the possibility of using chabazitic-zeolites mixed with the substrate to increase the rooting of ornamental crops such as Camellia and Leucospermum was evaluated. The results of the experiment showed a higher percentage of rooting of the cuttings placed in chabazite, compared to those in vermiculite, with a significantly increased level of microrrization.
Key-words: *inert materials, alternative substrates, rizosphere, plant roots, ornamental rooting*

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I. INTRODUCTION

Camellia is a genus of plants of the Theaceae family, native to the tropical areas of Asia. Includes shrub and sapling plants, evergreen, up to 15 meters high in nature. The most cultivated species as ornamental plant is the C. japonica L. (fig.1), native to Korea and Japan, shrub that reaches a few meters high, persistent leaves, oval dark green bright, spring flowering with flowers in various shades from white to dark red, corollas in the shape of open pink and flattened. For an optimal cultivation of camellias it is necessary to recreate as much as possible the natural environment in which they live: hilly or mountainous areas of humid subtropical areas, with cool climate and frequent rains, warm sun and good shading. Camellia sasanqua, a winter flowering camellia, is also widespread in the garden and sometimes blooms in November-December, depending on the climate; however, this camellia has much smaller flowers than the garden hybrids of C. japonica. In Italy is also cultivated the Camellia hiemalis, another camellia with early flowering, whose flowers bloom in winter, there are many hybrids of this camellia, even with large flowers and flashy [2].

The genus Protea comprises 117 species of evergreen shrubs characterized by rigid stems of 1-1,5 m; the leaves have an oval or elongated shape, of dark green colour and waxy. In summer, large inflorescences with a diameter of 10-25 cm are produced, formed by small flowers united at the centre, surrounded by long coloured bracts. The shape of the inflorescences varies according to the species: in some they resemble large artichokes, in others they are similar to coniferous cones.

In addition to being plants suitable for cultivation in terraces and gardens, Proteas can survive 2-3 weeks as cut flowers, and the most spectacular species, grown in series, feed a rich market [3]. These kinds of plants, both Camellia and Protea, often have problems in rooting, due to the percentage of cuttings that actually succeed in rooting and the time it takes to obtain quality seedlings that can survive in pots. The substrates normally used for these plants, consisting of mixtures of peat and perlite or other minerals in different percentages, do not always manage to overcome this problem. To overcome this problem, CREA-OF of Pescia (PT), has started in recent years experiments on the rooting of cuttings of Camellia Japonica and Leucospermum using mixtures of substrates to assess the effect on:

- percentage of rooted cuttings;
- time needed for the development of the roots;
- possibility of rooting without peat disks

In these experiments, zeolites, silicate alumina, have been used which have several interesting characteristics for use in agriculture. In particular, the cation exchange capacity (CSC) and the high molecular absorption capacity and hydrophilicity (reversible dehydration) that in horticulture and ornamental plants have provided numerous benefits. In particular, the use of zeolites in tomatoes [8], celery [1], courgettes and melons

[10], vegetables and fruit [11] has led to an increase in total production per hectare of land. In floriculture, the use of zeolites has led to an increase in height, in the total number of inflorescences, buds and flowers, in the size of the bulbs and to a higher precociousness of flowering in the geranium [9][10], lilium, gerbera, chrysanthemum, Liatris spicata, tulip, Cupressus sempervirens, olive trees, impatiens, Nerium oleander, Aloe, Echinopsis [14][15][16][17].

II. MATERIALS AND METHODS

Greenhouse experiment and growing conditions

The experiments began in early March 2018, were carried out price experimental greenhouses of the CREA-OF of Pescia (Pt), Tuscany, Italy (43°54′N 10°41′E) on plants of Camellia japonica cv Margherita and Leucospermum cv Succession (fig.2) . The cuttings (fig.3) , after being treated with rooting hormone, were placed in 54-hole plateaus, with electronically programmed irrigation turnover.

The characteristics of the chabazite (zeolite mineral group) used were:

1) qualitative-quantitative mineralogical analysis (% by weight with standard deviations in brackets) carried out by X-ray powder diffractogram according to the RIETVELDRIR methodology [6]: chabazite 66.2 (1.0); phillipsite 2.4 (0.5); mica 5.6 (0.6); K-feldspar 10.3 (0.8); pyroxen 2.2 (0.5); volcanic glass 13.3 (1.5);

2) Total zeolithic content (%): 68.6 (1.3), of which 66.2 due to chabazite and 2.4 from phillipsite. Cation exchange capacity (in meq/g with standard deviation in brackets) determined using the methodology described in [5],[7] :2.15 (0.15) of which 1.42 due to Ca, 0.04 to Mg, 0.05 to Na and 0.64 to K.

The cultivars of Camellia japonica and Leucospermum used were, respectively, Margherita and Succession. Young branches with a length of 7-12 cm have been cut from the mother plant. Subsequently, in order to reduce transpiration and dehydration, all the leaves were eliminated, leaving two of them and the buds at the top.

The experimental theses of the test were:

1) control J (CTRL-J): peat 50% + vermiculite 50% in peat disks, normally used by nurserymen;
2) control P (CTRL-P): peat 50% + vermiculite 50% without peat disks, directly on the plateau;
3) chabazite 10% J (CHABA-10%-J): peat 50% + vermiculite 40% + chabazite 10% in peat disks;
4) chabazite 10% P (CHABA-10%-P): peat 50% + vermiculite 40% + chabazite 10% on the plateau;
5) chabazite 20% J (CHABA-20%-J): peat 50% + vermiculite 30% + chabazite 20% in peat disks;
6) chabazite 20% P (CHABA-20%-P): peat 50% + vermiculite 30% + chabazite 20% on the plateau;
7) chabazite 30% J (CHABA-30%-J): peat 50% + vermiculite 20% + chabazite 30% in peat disks;
8) chabazite 30% P (CHABA-30%-P): peat 50% + vermiculite 20% + chabazite 30% in plateau.

The grain size of the chabazite used was 3-6 mm. 54 cuttings were used for 4 replicas for each thesis in a randomized experimental design. The measurements carried out at the end of the experiment on the plants were: percentage of rooting, rooting time, length and fresh weight of the roots.

Statistics

Collected data were analysed by one-way ANOVA, using GLM univariate procedure, to assess significant ($P \leq 0.05$, 0.01 and 0.001) differences among treatments. Mean values were then separated by LSD multiple-range test ($P = 0.05$). Statistics and graphics were supported by the programs Costat (version 6.451) and Excel (Office 2010).

III. RESULTS

The test showed that chabazite can significantly influence the biometric parameters that were considered for the rooting of Camellia japonica and Leucospermum cv Succession cuttings. In fact in (tab. 1) it is noted how the treatment with chabazite succeeds in increasing the percentage of rooted cuttings compared to the control in vermiculite, both in Camelia j. and Leucospermum. It varies from a rooting percentage of 60% in the control, to one of 80% in cuttings in chabazite 30%.

There are also effects on the average rooting time (tab. 2), in fact the zeolite plants in the two species under test, rooted more quickly, in proportion to the chabazite in the substrate.

Table 3, shows how treatment with 20% and 30% chabazite significantly increased the fresh weight of the roots compared to vermiculite control. Interesting aspect was found, as regards the length of the roots (tab.4) for both Camellia japonica and Leucospermum, it seems that the cuttings of the roots planted in chabasite, have a higher fresh weight, but that their length is significantly lower than the control in vermiculite. This has also been found in previous tests on Lilium, Chrysanthemum, Tulip.[17]

Probably the zeolites, in particular the chabazite, allow a lesser development in length of the roots, as the single minerals act as reserve zone for the water and the nutritive substances, which are slowly dispensed to the plants. As a result, root systems do not need to develop in length to meet their water and nutrient needs.

After one year of cultivation, zeolite-rooted cuttings have a significantly higher root volume than those obtained from peat and vermiculite alone[14][15].

Another interesting aspect seems to be the possibility to avoid the use of the peat disc, inserting the chabasite inside the plateau. The roots of the cuttings once rooted, in fact, can colonize the mineral avoiding the loss of substrate at the time of transplantation.

IV. DISCUSSION

Zeolites, as demonstrated by this test but also in previous experiments, can have multiple uses in horticulture.

These minerals, once introduced in the substrates of cultivation or in the open field, can optimize the growth of plants, have the ability to retain water and fertilizers and release them slowly, are also easy to use and are not harmful to man and the environment [4].

The results of the experiment showed a higher percentage of rooting of the cuttings placed in chabazite, compared to those in perlite, with a significantly increased level of microrrization. This effect was probably due to the improvement of water retention and nutrient availability in areas where zeolites were present, which stimulated the production of micro-roots [13].

These data underline some of the positive effects that chabazite could have when used in the rooting of cuttings of ornamental plants. The purity of the material used is particularly important. Determining the chemical-physical characteristics is in fact of particular importance in order not to run into problems during the cycle of cultivation in pots and in the open field [12].

V. CONCLUSION

The test showed that the addition of chabazitic-zeolites in a substrate, can improve the rooting capacity of plants that have difficulty in emitting roots such as Camellia japonica and Leucospermum. It also showed an improvement in root development that is more functional in the absorption of water and nutrients and provides greater possibilities to overcome water stress at the time of transplantation. Certainly important aspects in the world of floriculture, which make chabazitic-zeolites a valid alternative to conventional inert materials, to be added at the time of rooting.

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Tables

Table 1 - Effect of zeolites on the rooting percentage of Camellia japonica and Leucospermum cuttings

Rooting rate	Camellia	Leucospermum
CTRL-J	62.96	57.67
CTRL-P	63.89	59.72
CHABA-10%-J	65.74	62.50
CHABA-10%-P	67.13	65.74
CHABA-20%-J	76.85	74.54
CHABA-20%-P	81.02	79.17
CHABA-30%-J	77.31	80.56
CHABA-30%-P	81.48	88.89

Each value reported in the graph is the mean of three replicates ± standard deviation. Statistical analysis performed through one-way ANOVA. Different letters for the same parameter indicate significant differences according to LSD test (P = 0.05).

Table 2 - Effect of zeolites on the time of root formation of Camellia japonica and Leucospermum cuttings

Average rooting time (Days)	Camellia	Leucospermum
CTRL-J	182.25 a	173.75 a
CTRL-P	176.00 a	153.00 b
CHABA-10%-J	124.50 b	139.25 c
CHABA-10%-P	116.00 c	130.50 d
CHABA-20%-J	99.00 d	96.25 e
CHABA-20%-P	88.75 e	85.25 f
CHABA-30%-J	86.75 e	75.50 g
CHABA-30%-P	79.25 f	77.75 g

Each value reported in the graph is the mean of three replicates ± standard deviation. Statistical analysisperformed through one-way ANOVA. Different letters for the same parameter indicate significant differences according to LSD test (P = 0.05).

Table 3 - Effect of zeolites on the root fresh weight of Camellia japonica and Leucospermum cuttings

Root fresh weight (g)	Camellia	Leucospermum
CTRL-J	15.50 c	22.75 d
CTRL-P	15.75 c	23.00 d
CHABA-10%-J	17.00 bc	24.50 cd
CHABA-10%-P	17.00 bc	26.13 c
CHABA-20%-J	18.25 ab	31.14 b
CHABA-20%-P	19.25 a	33.25 ab
CHABA-30%-J	19.00 ab	32.75 ab
CHABA-30%-P	20.00 a	35.00 a

Each value reported in the graph is the mean of three replicates ± standard deviation. Statistical analysisperformed through one-way ANOVA. Different letters for the same parameter indicate significant differences according to LSD test (P = 0.05).

Table 4 - Effect of zeolites on the root lenght of Camellia japonica and Leucospermum cuttings

Root lenght (cm)	Camellia	Leucospermum
CTRL-J	13.00 a	16.25 a
CTRL-P	13.00 a	15.00 ab
CHABA-10%-J	12.75 a	13.75 bc
CHABA-10%-P	12.25 a	13.00 c
CHABA-20%-J	10.50 b	12.75 c
CHABA-20%-P	8.75 c	12.75 c
CHABA-30%-J	8.75 c	12.00 c
CHABA-30%-P	10.00 bc	12.25 c

Each value reported in the graph is the mean of three replicates ± standard deviation. Statistical analysis performed through one-way ANOVA. Different letters for the same parameter indicate significant differences according to LSD test ($P = 0.05$).

Figures

Fig. 1 - Detail of the flower of Camellia japonica

Fig 2 - Plants of Leucospermum cv Succession in cultivation

Fig. 3 - Evaluation of the rooting of Leucospermum cuttings

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