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Algerian sourced low-cost inorganic sustainable substrate for soilless cultivation

Ouaret walid*1, Salhi Zahreddine 1, Aitkaci Mazari 3, Ounane Sidi Mohamed 2

1 Mediterranean Agronomic Institute of Chania, Greece

2 Ecole Nationale Supérieure Agronomique, Algiers, Algeria

3 University of Science and Technology of Oran, Algeria

* Speaker and corresponding author: walid.ouaret@gmail.com

INTRODUCTION

Soilless production stands out as one of the best techniques for horticultural production, mainly based on substrate, the choice of this substrate is essential for its success. Gaining more and more importance in the world, the soilless cultivation technique is still very low in Algeria, despite the huge potential of its implementation. It helps to achieve better levels of production while overcoming the constraints of the soil (fertility decline, salinity, diseases ...), and makes possible the establishment of sustainable and reduced carbon footprint vegetable crops in larger semi-arid areas, with considerable water savings. However, the correct choice of the substrate and the adaptation of the production system to the local requirements, determine the success and the development of this technique.

The objective is to study the Pozzolan as substitute to Coconut fiber, currently used in Algeria as the main substrate in soilless cultivation. Despite its excellent technical performance, Coconut fiber has high cost of use and a high carbon footprint due to its long distance transportation (produced mainly in India and Sri Lanka). Unlike the Pozzolan which is largely abundant and easily accessible in the west of Algeria.

METHODS AND MATERIALS

Cultivation conditions -The tomato crop was cultivated at the facilities of CeviAgro SpA branch of Cevital group SpA, located at 36°43'20 N and 3°14'43 E, in Algiers (Algeria) on a one hectare plastic greenhouse (200 mm plastic cover).

The cultivation management scheme followed methods that are commonly used by the company. Table 1 shows the main cultivation parameters and the monthly maximum and minimum average temperatures recorded in the greenhouse.

Treatments **-** The treatments used were; Sand (S), Pozzolan (P) which are local products and Coconut fiber (F) an imported substrate. The Sand and Pozzolan were set up in white containers containing 30 kg (15.5 cm deep) trays, dimensions were 30 cm high by 30 cm wide with a length of 60 cm. The Sand is commonly utilized by the company to produce tomato transplant. Pozzolan used is a natural volcanic extract from Bouhamidi deposit located south of Beni

Saf wilaya of Ain Timouchente approximately 500 km to the west of Algiers. This Pozzolan is principally formed of slag and well stratified pumice stones, varying in color from red to black. The direct extraction and marketing of Pozzolan, produced by the FERPHOS® group, is primarily made for the construction industry. TheCoconut fiber peat comes in bags of 20 L, which are 120 cm long 14 cm high and 25 cm wide, produced by BIOGrow® and imported and distributed in Algeria by Cevital group SpA. Sand and Pozzolan were washed with Chloride (13° Chl) diluted in fresh water, and after that flushed before starting the experiment. The tomato variety used and chosen by the producer is PRISTYLA, a commercial variety of GAUTIER SEMENCE® group.

Experimental design and statistical analysis **-** The trial was conducted as a complete randomized block and the experimental unit comprised three culture units.

Fertigation conditions **-** For each treatment, two controls were established as fertigation controls, consisting of a control dripper and a drain pan that served as points for the measurement and monitoring of the supplied fertigation and the absorption response. At these locations, the volume of the nutrient solution as well as the pH and electrical conductivity (EC) of the fertigation input and the drainage were measured on a daily basis. The macro and micronutrient composition of the nutrient solution was the same for all treatments and set up based on the common recipe used at CeviAgro SpA following the proposal of (Sonneveld & Voogt 2009). The physical, physical–chemical, and chemical characteristics were determined for the three substrates.

Harvest sampling **-** Tomatoes were harvested once they had reached a state of maturity corresponding to a uniform red color of the tomato skin. The tomatoes were weighted and then sized according to their equatorial diameter, a subsample of three tomato fruits was used to produce a homogenized solution to quantify the pH, EC, and total soluble solids (expressed as Brix), which were measured with a digital refractometer.

Economic approach **-** the economic appraisal of our experiment is based on a comparative study between how much it would cost to grow one tomato plant using the conventional imported Coconut fiber and the locally produced Pozzolan.

By making the cultivation conditions for both methods homogeneous, we were able to neutralize the effects of overheads and fixed costs. Thus we managed to narrow our concentration on the differences between costs of purchasing and transporting the Coconut fiber and those of purchasing and transporting the Pozzolan, over a cultivation period of ten years

Table1: Main parameters of culture cycles done during the assays.

Plantation density (plants/m2)	Transplant date	Harvesting date	Final harvesting date	Min Temp °C	Max Temp °C
1	26-sept-12	08-janv-13	28 May 2013	8,2	44,1

RESULTS AND DISCUSSION

Figure 1:Texture and particle size distribution (% weigh) of Pozzolan substrate before and after the cultivation.

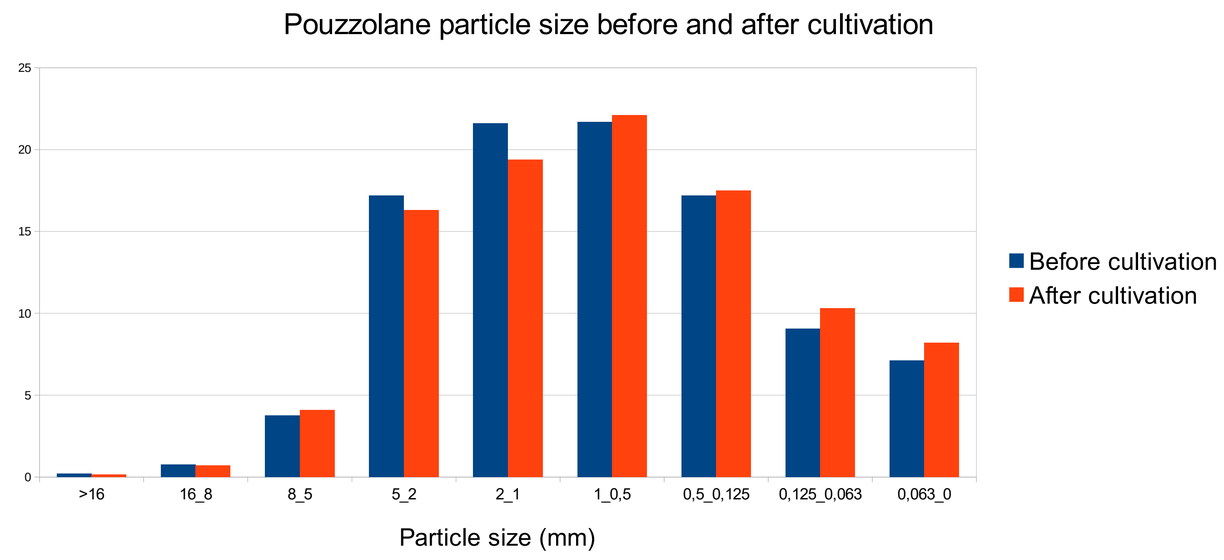

Table 2. Fruit quality parameters, average caliber size, yield and number of fruit per harvest according to the Pozzolan,Coconut fiber substrate and Sand.

Treatments	°Brix	pH	EC (dS/m)	Yield (kg/m²)	Caliber (cm)	Fruit/m²
Pozzolan	3,8	4,066	4,3	7,89	7,83	34,66
Coconut fiber	4,1	4,04	4,12	8,1	7,6	32,43
Sand	3,95 **NS**	4,066 **NS**	4,50 **NS**	8,2 **NS**	7,47 **NS**	30,57 **NS**

*, **, NS indicate significant differences at P ≤ 0.05, P ≤ 0.01 and non significant differences, respectively.

Table 3. Drainage parameters according to Pouzzolan, Coconut fiber and Sand..

Treatments	Drain (%)	Drain pH	Drain EC (dS/m)
Pozzolan	30,67	7,18	2,3
Coconut fiber	24,43	7,2	2,65
Sand	50,01**	7,17 **NS**	2,40 **NS**

*, **, NS indicate significant differences at P ≤ 0.05, P ≤ 0.01 and non significant differences, respectively.

Economic approach - We found that the cost of using the Coconut fiber substrate is 0.89 € per plant, which has a utilization duration of three years. The cost of the Pozzolan use is 0.37 € per plant, which has a utilization duration of ten years. Over a period of ten years, our calculations showed that the Coconut fiber substrate is **six times more expensive** than the Pozzolan. The comparative study clearly indicates that using the locally produced Pozzolan is much more economically viable than using the imported Coconut fiber substrate.

CONCLUSION

The parameters measured to characterize the Pozzolan of Beni Saf indicate that there is no limitation to its use as a growing medium for soilless cultivation. The yield and quality performance of the product obtained, by the use of Pozzolan substrate, being similar to that of Coconut fiber opens the possibilities to use it as a local alternative substrate; especially due to the fact that it requires very low energy to manufacture it and the reduced transportation costs, compared to the Coconut fiber, which significantly reduce the carbon footprint. However, additional studies with greater detail of its physical, physicochemical and chemical characteristics are necessary in order to adapt the fertigation and the nutrient solution recipe for optimal use. Furthermore, the comparative cost study showed that the use of the Pozzolan has a production cost six times lower than that of Coconut fiber substrate. The abundance of Pozzolan in Algeria and its cost efficiency make it a more appropriate sustainable solution to guarantee food safety with a reduced carbon footprint. In addition, the use of Pozzolan has indirect economic benefits such as reducing or eliminating the import costs of the Coconut fiber, developing an extraction industry, distribution channels and creating permanent job opportunities.