Sugarcane pulp residue as a horticultural substratum and as an organic corrective

J. Brito, I. Chada, P. Pinto, C. Guerrero, and J. Beltrão

Abstract— This work aims to justify the use of sugarcane residues as soil organic amendment and the possibility to be applied as a substratum in the green pepper culture *Capsicum annuum* L. Several treatments of mixtures of soil and sugarcane residues were used, with increasing doses in the following percentages 0%, 25%, 50%, 75% and of 100% of sugarcane residues. Weekly evaluations of the biometrical parameters of each treatment were determined, such as the height, the stem diameter, the number of leaves and number of floral buttons, the SPAD units in new and old leaves and the number of developed fruits. Laboratorial analysis were done in order to evaluate chemical parameters on the end of the experimental work ─ pH, the electric conductivity and the concentration of N, P, K, Mg, Ca, Fe, Cu, Mn e Zn soil and sugarcane residues mixtures. It can be concluded that sugarcane residues have characteristics of a good soil organic compost, and can be used in soils poor in organic matter, and t6contribute to increase the soil fertility level. Moreover, it was observed some root development, according to the increase of sugarcane residues applied in the mixtures. Plants growing in the 100% sugarcane residues mixture showed a satisfactory behavior, probably due to a better soil aerification, which had promoted root development.

Keywords — biological and chemical parameters, biosolids, carbon recycling, organic amendment, reuse

I. Introduction

The population increase and the industrial development produce an enormous amount of organic residues that nowadays generate great environmental problems. The appropriate agricultural use of these residues can become advantageous for the mankind because it allows nutrients recycling, improve crop production, less pollution problems, and as well the improvement of the physical, chemical and biotic conditions of the soils.

In certain areas, the soil is poor in organic content, and therefore needs organic amendment. In the last decades, the substratum growth crops is winning prominence in the world scenery [6], due to the problems originated by the traditional crops in soil. It has begun by re-using the sewage sludge [5] for several horticultural [1]-[13]-[14], ornamental [2], and forest [21] crops. Later, the sewage sludge was compared with other commercial substrata, like peat [17]. For a long time, different types of commercial substrata have been used in nursery-gardens, such as fertilized or unfertilized peat, with or without sand or other inert products. As an example of the use of commercial substrates is the use of peat, which has some problems, namely high price, according to its extraction and transportation costs and limited sources [18]. Moreover, its deposit conditions the local fixation of atmospheric carbon dioxide and their destruction allows an increase of that gas in the atmosphere [20]. Diseases may appear faster in peat medium, when some pathogenic agents could be propagated when un-sterilized peat is used [7]. So, alternative substrata can be used with the same or better results than peats [16], namely tree barks, wood shreds and others [19] like the sugarcane residues – the present study.

The advantages of the use of sugarcane residues are multiple – the sugarcane residues can decrease the proliferation of pathogens, the salinity of the soils, the use of water and nutrients; hence, the use of less aggressive production systems is applied to the environment [4]. On the other hand, generally biosolid residues, namely sewage sludge residues have other non-environmental destinations, such as - the sea (presently forbidden), the deposition in landfields, incineration (in the developed countries).

An excellent substratum depends on the techniques used on its production, on the type of the vegetable material, climatic conditions, water content and some economical aspects.

The sugarcane is a grassy crop that produces, in a short period, a high income of biomass, energy and fibres, being considered one of the plants with larger photosynthetic efficiency. Its plantation, in a wide scale, is traditional in several countries of the tropical and subtropical regions for the production of sugar, alcohol and other bio-products. Several tons of sugarcane residues are produced and need to be conditioned. Experiments have been conducted to study the viability of those residues on wheat production [9]-[15], as horticultural substrates mixes [12], as nematicide on mandarin culture [10], or as fish feeds [22]. Sugarcane residues are a source of vegetal fibres that have potential use on the industry

Manuscript received May 12, 2007: Revised version received Aug.16, 2007
This work was supported by EIBOL Group (Valencia - Spain) and Benamor Golf Course – (Algarve - Portugal).

J. Brito is Professor Agregate at the Faculty of Natural Resources Engineering of the University of Algarve – Portugal (corresponding author; e-mail: jbrito@ualg.pt; phone: +351 289800936)

I. Chada is a technical Agronomic Engineering at a plant production enterprise.

C. Guerrero is Professor Assistant at the Faculty of Natural Resources Engineering of the University of Algarve – Portugal (e-mail: cguerre@ualg.pt; phone: +351 964492818)

P. Pinto is a technical Agronomic Engineering at a plant nursery enterprise.

J. Beltrão is Senior Professor at the Faculty of Natural Resources Engineering of the University of Algarve – Portugal (e-mail: jbeltrao@ualg.pt)

of polymeric composites [8]. All these potential uses have the major goal of resolve the disposal problems of sugarcane residues production.

This work had as main objective to study the use of the sugarcane pulp, final residue of the processing of the sugarcane as an organic soil amendment and simultaneously to verify its possibility as a substratum. The culture chosen for the experiment was green pepper (*Capsicum annuum* L.), a horticultural plant well adapted to high temperatures.

II. Material and Methods

A. Experimental procedure

The study was carried out in an investigation greenhouse, in the "Horto" of the Faculty of Natural Resources Engineering at the University of Algarve.

The crop used in this experiment was *Capsicum annuum* L., variety *Lamuyo*, sowed in alveolated nursery. It was used a topsoil layer from a Haplic Arenosol (ARha) according to World Reference Base for Soil Resources [11]. The straw pieces were pressed and the dimensions of the sugarcane residues were reduced, through the use of pruning scissors. The experiment was accomplished in a 24 cm diameter pots (5 L volume), distributed randomly in three replications, according to the following treatments (v/v):

Treatment 1 - 0% of sugarcane residue (SR); Treatment 2 - 25% of SR + 75% of soil; Treatment 3 - 50% of SR + 50% of soil; Treatment 4 - 75% of SR + 25% of soil; Treatment 5 - 100% of SR (as a horticultural substratum).

B. Plant growth measurements

Plant growth was evaluated along the experimental period. At weekly interval it was recorded plant height (cm), the number of leaves, the diameter of stems and the green colour intensity (chlorosis degree) of the new and old leaves (SPAD measurements).

C. Laboratorial analysis

On the end of the experiment, the separation of the leaves and of the stem was done and their weights were registered and the biomass of the aerial part was determined. Organic matter content, pH, EC, N, P, K, Ca, Mg, Fe, Zn, Cu and Mn, of the soil, sugarcane residues and soil-sugarcane residues mixtures were analysed.

D. Statistical analysis

Chemical analyses and plant biometric values had been submitted to a variance analysis (ANOVA); differences were considered significant when $p<0.05$. Normality of sample distribution and homogeneity of variances were verified before ANOVA [23]. The comparative analysis of the treatment averages was realized through the New Multiple-Range Test [9]. For the statistical analysis it was used the SPSS ver. 14.0 (SPSS Incorporation, 1989-2005, Chicago, Illinois, U.S.A.) and the Microsoft Excel (Office 2003).

III. Results

Fig. 1 presents the values of the evolution of the vegetative growth of the plants, according to their height (cm) along the experiment. Plants were higher where no sugarcane residue was applied, followed with the 75% soil – 25% sugarcane mixture.

Fig.2 shows the values of the green colour chlorosis degree according to the SPAD value of the new leaves, along the experiment. According to SPAD values, plants had darker green colour at 0%, 25 and 50% sugarcane mixtures.

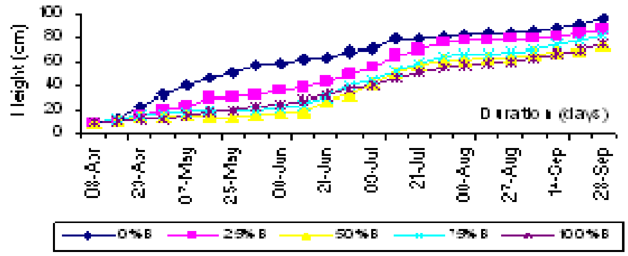

Fig. 1. Plant height (cm) along the experimental period. Averages with the same letter do not present significant differences at 95% (multi average comparison - Duncan test)

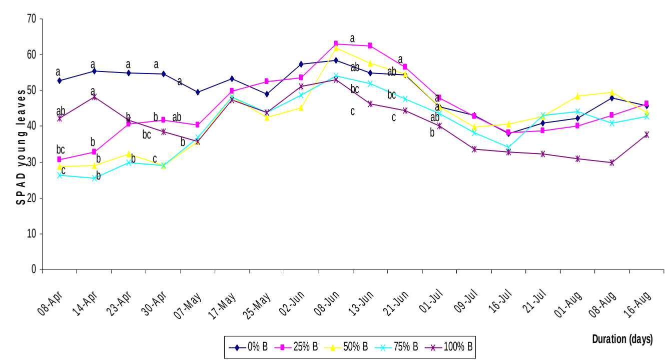

Fig. 2. SPAD values of the new leaves in the different treatments, along the experiment. Averages with the same letter do not present significant differences at 95% (multi average comparison - Duncan test)

Fig. 3 shows the N, P, K Ca contents of pepper leaves, at the end of the experiment.

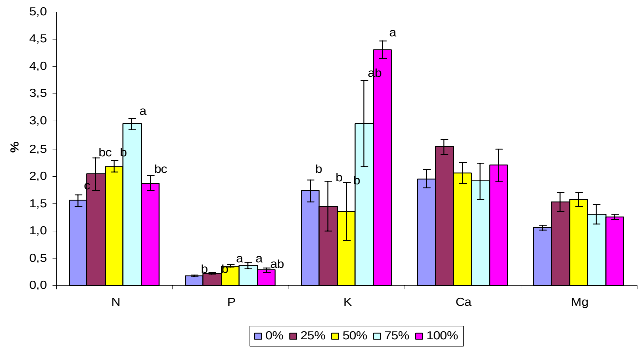

Fig. 3. N, P, K, Ca and Mg contents in pepper leaves, for the different treatments at the end of the experiment. Averages with the same letter do not present significant differences at 95% (multi average comparison - Duncan test)

Fig. 4 shows Fe, Mn, Zn and Cu contents of pepper leaves, at the end of the experiment.

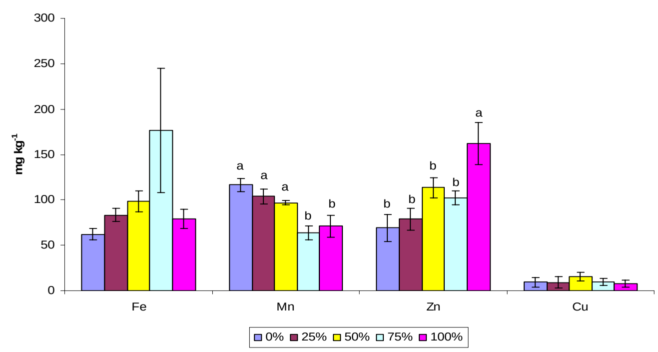

Fig. 4. Fe, Mn, Zn and Cu contents of pepper leaves at the end of the experiment. Averages with the same letter do not present significant differences at 95% (multi average comparison - Duncan test).

Table 1 shows the sugarcane residues chemical analyses at the beginning and at the end of the experiment (pH, electrical conductivity (EC), C/N ratio, organic matter, N, P, K, Ca, Mg, Fe, Cu, Mn, Zn contents).

Table 2 shows the values of the chemical parameters (pH, electrical conductivity (EC), C/N ratio, organic matter, N, P, K, Ca, Mg, Fe, Cu, Mn, Zn contents in soil - sugarcane residues mixtures at the end of the experiment for Treatments 1, 2, 3 and 4 (0 %, 25%, 50% and 75 % of sugarcane residues, respectively).

Table 1. Chemical analysis of the sugarcane residues at the beginning (B) and at the end (E) of the experiment

Parameters	B	E
pH	5.2	7.3
EC (dS m^{-1})	1.0	2.4
Organic matter (%)	96.5	84.0
C/N	147.0	40.2
Nitrogen (%)	0.4	1.2
P (%)	0.1	0.4
K (%)	0.7	0.4
Ca (%)	0.1	0.8
Mg (%)	0.1	0.6
Fe (mg.kg^{-1})	479.3	1821.4
Cu (mg.kg^{-1})	13.8	22.5
Mn (mg.kg^{-1})	33.5	96.5
Zn (mg.kg^{-1})	20.5	91.9

Table 2. Chemical parameters in the soil-sugarcane residues mixtures at the end of the experiment. Averages with the same letter do not present significant differences at 95% (multi average comparison - Duncan test)

Parameters	**T1**	**T2**	**T3**	**T4**
pH	8.37	8.20	8.23	7.91
CE (dS m^{-1})	0.05 b	0.06 b	0.07 b	0.21 a
Organic matter (%)	1.24 b	1.05 b	1.57 b	2.58 a
C/N	17.98	12.18	15.17	14.97
N%	0.04 b	0.05 b	0.06 b	0.10 a
P_2O_5 ppm	10.95	9.20	6.86	8.25
K_2O ppm	10.16 b	15.70 b	16.88 b	83.69 a

IV. Conclusions

Portuguese soils, especially thus on the south, are usually poor in organic matter content, once that the local weather increases mineralization. Hence, this work shows that the use of the sugarcane residues has potential to be a reasonable soil organic amendment, increasing soil fertility and improving crop production.

It was observed that the Treatment 2 (75% of sugarcane residue + 25% of soil) had a higher significant organic matter content increase than the Treatments 1, 2, and 3 (0%, 25% and 50% of sugarcane, respectively). It was verified in Treatment 4 (75% of sugarcane) a higher root development. Sugarcane residues might contribute for higher soil porosity and contribute to a better gas exchange at the soil atmosphere. Sugarcane residues as a soil organic amendment have potential to provide lower soil bulk density, higher porosity and also higher water availability [6].

Treatment 5 (100% of sugarcane) presented a satisfactory behaviour, during the vegetative cycle of the crop.

According to sugarcane residues initial C and N contents, and consequently to its C/N ratio, it seems that submitting sugarcane residues to a composting process treatment before its agricultural use it will allow the achievement of an organic product (compost) with a lower C/N ratio, improving its mineralization and nutrients availability, especially on N uptake by plants [3]. Results showed a great interest for the use of these kind of experiments. And, therefore, other experiments should be done for other species under various other types of substrates, increasing yields and improving the energy, environment, ecosystems and the sustainable development.

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NOTE: This paper was presented at the 3rd IASME / WSEAS International Conference on ENERGY, ENVIRONMENT, ECOSYSTEMS and SUSTAINABLE DEVELOPMENT, Agios Nikolaos, Crete Island, Greece, July 24-26, 2007.