Commercial crop production of lettuce, irrigated on seedling stage with effluent from anaerobic digestion of dairy cattle manure.

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Abstract

The organic wastes of dairy cattle can be treated anaerobically to obtain biogas, mud and effluent. The effluent is a liquid rich in mineral salts and humid acids, which can be used as a source of nutrients for plants, irrigation water for immediate use or stored for future applications The feasibility of using anaerobic digestion(AD) effluent as organic fertilizer is mention in international literature. In addition, different experiences show that the use of effluent in horticultural production increase yields.

The aim of this study was to evaluate the effect of irrigation of effluents in stage of seedling on the commercial production of lettuce.

Manure was obtained from dairy installation of the National University of Luján, Buenos Aires, Argentina (35º 35' S, 59º W, 28 m over sea level). A discontinuous load digester was built to pilot scale, using 25 liter glass bottles placed in stove at 37 +/- 1 °C. To assure treatment efficiency and good nutrient yield, the material used for digestion process contained 4 % of total solids.

The digestion process was concluded when biogas production diminished compared to the maximum registered values, approximately 3 ½ months after process initiation. At the beginning and at the end of the process, the material was analyzed by chemical and microbiological tests according to APHA Norms (1992). Seedlings were produced in a greenhouse during winter season. Lettuce cv. Galician seeds were sowed in cell trays, using a commercial substrate, composed by crowd, pearl and pine composted bark. The effluent was manual pulverized with in weekly basis, using three different effluent:water dilutions plus a control.. When plants were on transplant stage (4 true leaves), dry weight and leaf area of plants from each treatment were measured, according to the methods describes by Gardner *et al*. (1995) and fifteen seedlings of each treatment were transplanted to pots with silica sand as substrate. Commercial yield was evaluated by fresh weight at harvest. The essay was carried out in a complete randomized design with 15 replications.

Data were evaluated by variance analysis, and differences among means studied by LSD ($p < 0.005$). Irrigation with effluent dilutions in the nursery phase produced higher values of dry weigh and leaf area on lettuce seedling (Puerta et al., 2007), increasing crop production at harvest by 83 % in D2, 55 % in D1 and 48 % in D3, compared to control plants. Higher dilutions of effluent improved seedling quality, maintaining this advantage during crop production and yield at harvest.

Introduction:

Development of any productive activity and semi-intensive animal production involve the generation of waste, producing changes in the ecosystem. The accumulation of these residues promote the commodity output and the energy of the system, interrupting the normal processes of cycles (Diaz and Rolando 2000). AlphaIn self-sustaining systems, waste should rejoin the natural cycle of matter in the form of raw materials at any stage of the process. Waste treatment allows to recover these residues and reintegrate them into the cycle. Anaerobic digestion (AD) is a method of treatment where anaerobic bacteria transform complex organic compounds in structures inorganic simple. As a result of this process, gets biogas (an alternative source of energy) and "effluent" (a liquid composed of organic matter stabilized, salts, minerals and organic acids).

Both products drive the system towards the self-sustainability by also reducing production costs.

Effluents could be used as biofertilizer because of its content in soluble nutrients, easily available for plant absorption (FAO, 1987; FAO, 1984). Moreover, during the process of AD the reduction of bacterial pathogens is greater than a 90%. In the area of influence of the University of Lujan, lettuce production is one of the main activities of many of horticultural producers that coexist with establishments dedicated to dairy production and other intensive animal productions which generate significant quantities of waste. To use untreated solid and liquid waste from animal origin is a common practice . As that is not a proper farming practice , there it is to study viable Several authors report that the use of effluent applied to horticultural crops generates increases in yields (Renuka y Sankar, 2001; Bogliani, 1988; Gerber, 1988).
The aim of this study was to evaluate the effect on lettuce crop production of the irrigation effluent from anaerobic digestion of dairy cattle manure on lettuce seedlings

Material and Methods

Obtaining the effluent:
Manure was obtained from dairy installation of the National University of Luján, Buenos Aires, Argentina (35º 35' S, 59º W, 28 m over sea level). A digester of discontinuous load was built to pilot scale, using 25 liter glass bottles placed in stove at 37 +/- 1 °C. To assure treatment efficiency and good nutrient yield, the material used for the digestion process contained 4 % of total solids. The digestion process was concluded when biogas production diminished compared to the maximum registered values, approximately 3 ½ months after process initiation. At the end of the process, the material was analyzed by chemical and microbiological tests according to APHA Norms (1992), determining percentages of total solids (%TS), fixed solids (%FS), volatile solids (%VS), chemical oxygen demand (COD) pH, electrical conductivity (EC), total nitrogen and potassium on dry base (%NK), total phosphorus on dry base (%P) and potassium on wet base. Sanitary quality was evaluated through analysis of potential residues for the agricultural media, coliform bacteria and faecal Streptococcus.

Application of effluent to lettuce seedling:
Seedlings were produced in a greenhouse during winter season. Lettuce (Lactuca sativa L.) var. Galician seeds were sowed in cell trays, using a commercial substrate, composed by crowd, pearl and pine composted bark. The effluent was manual pulverized with a weekly frequency, using three different effluent:water dilutions and a control without effluent addition. Dilutions were: D I dilution 1:9, D II dilution 1:6 and D 3 dilution 1:3. When plants were on transplant stage (4 true leaves), fresh and dry weight of leaves and root, height and leaf area of plants from each treatment were measured, according to the methods describes by Salisbury & Ross (1985) and Gardner et al. (1995).
The essay was carried out in a complete randomized design with six replications. Data were evaluated by variance analysis, and differences among means studied by LSD ($p < 0.005$).

Selection of seedlings for transplanting and evaluation of commercial yield of plants at harvest:
When plants were reaching 4 true leaves fifteen seedlings of each treatment were transplanted to pots with silica sand as substrate. Commercial yield was evaluated by fresh weight at harvest.

Results

The effluent obtained by AD presented characteristics consistent with an organic leaf fertilizer, appropriate to the fertilization of lettuce by its contents in nitrogen, phosphorus and potassium. One of the considerations to take into account, in applying this type of effluent is that they have high electrical conductivity (Table 1), which may cause phytotoxicity and damage the commercial quality of the plant. For this reason, in this trial were tested three different effluents: water dilutions.

TABLE 1: Effluent chemical characterization after digestion process

VARIABLES	Effluent
Total Solids [%]	0.8
Fix Solids [%]	33.9
Volatile Solids [%]	66.1
Chemical Oxygen Demand [mg.l^{-1}]	10,333
pH	7.9
Electrical Conuctivity [mmhos.cm^{-1}]	5.9
Total Nitrogen [% dry]	5.5
Phosphorous[% dry]	1.72
Potassium [mg.l^{-1}, wet]	1200

Seedlings watered with effluent dilutions achieved better quality parameters, with higher values of fresh and dry weigh, height and leaf area, differing statically from control plants. Higher increments were obtained with 1:3 and 1:6 dilutions (Table 2)

TABLE 2: Plant height, root and leaf fresh and dry weight and leaf area of lettuce (*Lactuca sativa* L.) var. Galician plants at 4 true leaves stage

TREATMENTS	CONTROL	1:9 DILUTION	1:6 DILUTION	1:3 DILUTION
PLANT HEIGHT	4.97 a	6.62 b	8.49 c	8.72 c
ROOT FRESH WEIGHT	0.45 a	0.55 b	0.62 c	0.63 c
LEAF FRESH WEIGHT	0.48 a	0.68 b	1.01 c	1.09 c
ROOT DRY WEIGHT	0.0384 a	0.0436 b	0.0462 b	0.0458 b
LEAF DRY WEIGHT	0.0601 a	0.082 b	0.101 c	0.100 c
LEAF AREA	17.47 a	25.88 b	39.63 c	42.04 c

Plants from seedlings irrigated with different dilutions of effluent showed a better commercial yield which was manifested by an increase in fresh weight of plants. Crop production at harvest increased by 83 % in 1:6 dilution, 55 % in 1:3 dilution and 48 % in 1:9 dilution, compared to control plants. Higher dilutions of effluent improved seedling quality, maintaining this advantage during crop production and yield at harvest.

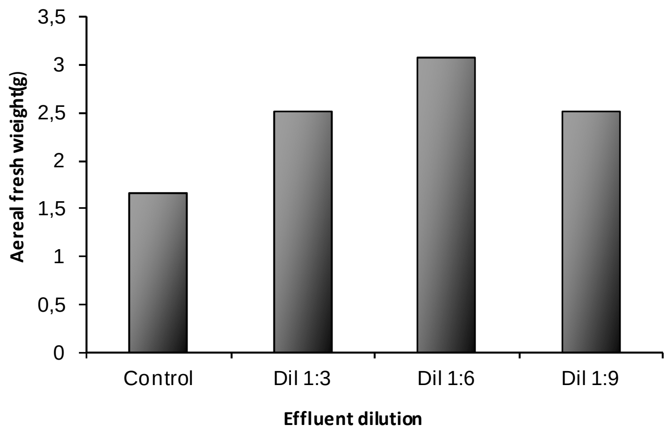

Figure 1: Fresh matter yield in different effluent application

Conclusion

The use of effluent derived from AD proved to be effective as fertilizer in seedbed stage, producing higher quality seedlings, which had a direct effect on the quality and commercial yield of lettuce at harvest.
Furthermore, the use of effluent derived from AD for fertilization of horticultural crops, would be an appropriate method for disposal of organic waste.

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