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# TECHNOLOGY FOR SUGARCANE AGROINDUSTRY WASTE REUSE AS GRANULATED ORGANOMINERAL FERTILIZER

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**ABSTRACT**: Aiming to evaluate the use of sugarcane industry waste such as byproducts from vinasse concentration process, it was assessed the organomineral fertilizer BIOFOM (concentrated vinasse, filter cake, boiler ash, soot from chimneys and supplemented with mineral fertilizers). The study included characterization and agronomic potential analysis of a test plant (corn), by noting the differences between mineral fertilizers and BIOFOM fertilization until 45 days after sowing. The technology traditionally used to produce BIOFOM was based on vinasse evaporation with high heat transfer coefficients. It was observed that the technology, which can be formulated according to the needs of any crop, could be used in many cases as mineral fertilizer. Therefore, the use of this organomineral fertilizer reduces waste generation of sugarcane industry.

**KEYWORDS**: biofertilizer, vinasse, sugarcane agribusiness, organic waste, filter cake.

# TECNOLOGIA PARA APROVEITAMENTO DE RESÍDUOS DA AGROINDÚSTRIA SUCROALCOOLEIRA COMO BIOFERTILIZANTE ORGANOMINERAL GRANULADO[1]

**RESUMO**: Com o objetivo de avaliar o uso de resíduos da agroindústria sucroalcooleira como vantagens do processo de concentração da vinhaça, utilizou-se o BIOFOM (biofertilizante organomineral formulado com vinhaça concentrada, torta de filtro, cinzas de caldeira e fuligem das chaminés, e complementado com fertilizantes minerais). O presente estudo contemplou a caracterização e a análise do potencial agronômico envolvendo uma planta-teste (milho), observando as diferenças entre os tratamentos (adubação com fertilizante mineral *versus* adubação com BIOFOM), até 45 dias após a semeadura. A tecnologia (tradicionalmente usada para a produção do BIOFOM) utilizada para concentrar a vinhaça baseou-se na evaporação do resíduo com elevados coeficientes de troca térmica. Observou-se que o BIOFOM, que pode ser formulado de acordo com as necessidades de qualquer cultura, pode substituir, parcial ou totalmente, a utilização do fertilizante mineral. O produto reduz a geração de resíduos da agroindústria sucroalcooleira.

**PALAVRAS-CHAVE**: biofertilizante, vinhaça, agroindústria canavieira, resíduos orgânicos, torta de filtro.

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[1] The present paper is part of the first author's dissertation presented to the FEAGRI-UNICAMP, being a major accomplishment to obtain PhD degree in Agricultural Engineering.

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## INTRODUCTION

The National Alcohol Program (PROALCOOL), created in 1975 to stimulate the production of ethanol in order to meet the needs of the domestic and foreign markets and the automotive fuels policy (SILVA & FISCHETTI, 2008), first drove the remarkable expansion of sugarcane farming. From this date, a major expansion of sugarcane activity was promoted in Brazil, as well as its concentration in certain areas and agricultural regions, especially in areas of the state of São Paulo. The second major thrust in sugar cane industry was the introduction of vehicles powered by gasoline and ethanol (flex-fuel) in 2003, and the worldwide movement pro-use of renewable fuels, from the mid-2000s on (RAMOS et al., 2008).

The environmental issue, however, has not received the same concern as the increase in production. Essential factors for sustainable development of sugarcane production were never taken into account. With population growth, in the vast majority urban, and increased industrial development, water and solid wastes have been generated in large quantities (TASSO JÚNIOR et al., 2007). This fact resulted in intensification of major environmental problems such as degradation of ecosystems, atmospheric pollution caused by fires and pollution of watercourses and groundwater caused by excessive application of vinasse “in natura” (SZMRECSÁNYI, 1994).

Some successful experiences with waste management in power plants and distilleries show that the filter cake, solid organic material obtained from sugar production, has been used in the fertilization of sugarcane crops. The sugarcane bagasse, which was already being used to generate energy in industrial units, has also been used in recent years in energy cogeneration, allowing power plants and distilleries not to consume electricity from distribution networks.

Vinasse is a byproduct from alcohol manufacture, being composed mostly of water (CÓ JUNIOR et al., 2008) and is the main effluent of the distilleries by fermentation, which had previously released directly into rivers, causing severe environmental problems. Nowadays, it is largely used to irrigate and fertilize sugarcane fields. It must be mentioned that the use of wastes deserves attention for possible problems concerning soil and water degradation and contamination (SPADOTTO, 2008).

Since waste production from sugarcane processing is quite voluminous, for both ethanol and sugar, the search for appropriate technologies to promote the management, treatment and use, constitutes a determining factor for an environmentally sustainable development of the sugarcane agro-industrial complex.

In this context, this research aimed to evaluate a patented organic fertilizer and commercially known as BIOFOM produced with waste from sugar and alcohol industry (concentrated vinasse, filter cake, boiler ash and soot from chimneys), and supplemented with mineral fertilizers to obtain equivalent formulations to those used in conventional fertilization of sugar cane.

## MATERIAL AND METHODS

The experiment with BIOFOM, using corn as "test plant", was carried out from October to December 2008 in a greenhouse at the Department of Soil Sciences from the "Luiz de Queiroz" College of Agriculture, University of São Paulo, in Piracicaba (SP), Brazil. The location is at 547 meters of altitude and 22º 43' 31" S latitude and 47º 38' 57" W longitude. The greenhouse has 200 $m^2$, with East-West orientation and plastic cover, and a moistened air circulation through a Pad House system performed the environmental cooling.

The agronomic potential of BIOFOM was evaluated through fertilizer lots that were produced with vinasse, filter cake, ash and soot; and supplemented with chemical fertilizers and granulated.

As shown in the Table 1, the experimental design was in randomized blocks consisting of 25 treatments and four replications: (i) Control; (ii) Molasses vinasse BIOFOM + broth with 30% and 45% of total soluble solids (TSS) + 50%, 75% and 100% mineral fertilizer; (iii) Molasses vinasse BIOFOM with 30% and 45% of TSS + 50%, 75% and 100% of the mineral fertilizer dose; (iv)

Broth vinasse BIOFOM with 30% and 45% TSS + 50%, 75% and 100% of the mineral fertilizer dose; (v) Mineral fertilizer equivalent to 100%, 75% and 50% of the dose; (vi) Molasses vinasse + concentrated broth at 30% of TSS + complement; (vii) Concentrated molasses vinasse at 30% of TSS + complement and; (viii) Concentrated broth vinasse at 30% of TSS + complement. The comparisons of the differences between treatments were performed by Tukey test (significance level of 5%). For statistical analysis it was used the software SAS 9.2 (*Statistical Analysis System*).

TABLE 1. Treatments (T) of the experiment to evaluate the Biofom with corn (test plant).

| T | Composition | Abreviation |
|---|---|---|
| **1** | Control: soil corrected with limestone | Control |
| **2** | Molasses vinasse BIOFOM + broth with 30% of total soluble solids (TSS) + 50% mineral fertilizer (0.823g of urea, 1.626 g of triple superphosphate and 1.289 g of KCl) | Mixed 30-50 |
| **3** | Molasses vinasse BIOFOM + broth with 30% TSS + 75% mineral fertilizer dose (1.234 g urea, 2.439 g of triple superphosphate and 1.933 g of KCl) | Mixed 30-75 |
| **4** | Molasses vinasse BIOFOM + broth with 30% TSS + 100% mineral fertilizer dose (1.645 g urea, 3.252 g of triple superphosphate and 2.577 g of KCl) | Mixed 30-100 |
| **5** | Molasses vinasse BIOFOM + broth with 45% of ST + 50% mineral fertilizer dose | Mixed 45-50 |
| **6** | Molasses vinasse BIOFOM + broth with 45% of TSS + 75% mineral fertilizer dose | Mixed 45-75 |
| **7** | Molasses vinasse BIOFOM + broth with 45% of TSS + 100% of the mineral fertilizer dose | Mixed 45-100 |
| **8** | Molasses vinasse BIOFOM with 30% of TSS + 50% of the mineral fertilizer dose | Molasses 30-50 |
| **9** | Molasses vinasse BIOFOM with 30% of TSS + 75% of the mineral fertilizer dose | Molasses 30-75 |
| **10** | Molasses vinasse BIOFOM with 30% TSS + 100% of the mineral fertilizer dose | Molasses 30-100 |
| **11** | Molasses vinasse BIOFOM with 45% of TSS + 50% of the mineral fertilizer dose | Molasses 45-50 |
| **12** | Molasses vinasse BIOFOM with 45% of TSS + 75% of the mineral fertilizer dose | Molasses 45-75 |
| **13** | Molasses vinasse BIOFOM with 45% of TSS + 100% of the mineral fertilizer dose | Molasses 45-100 |
| **14** | Broth vinasse BIOFOM with 30% TSS + 50% of the mineral fertilizer dose | Pure 30-50 |
| **15** | Broth vinasse BIOFOM with 30% TSS + 75% of the mineral fertilizer dose | Pure 30-75 |
| **16** | Broth vinasse BIOFOM with 30% TSS + 100% of the mineral fertilizer dose | Pure 30-100 |
| **17** | Broth vinasse BIOFOM with 45% of TSS + 50% of the mineral fertilizer dose | Pure 45-50 |
| **18** | Broth vinasse BIOFOM with 45% of TSS + 75% of the mineral fertilizer dose | Pure 45-75 |
| **19** | Broth vinasse BIOFOM with 45% of TSS + 100% of the mineral fertilizer dose | Pure 45-100 |
| **20** | Mineral fertilizer equivalent to 100% of the dose (500 kg of 4-20-20 (N, P, K) + 30 kg of N in coverage) * | Mineral 100 |
| **21** | Mineral fertilizer equivalent to 75 % of the dose | Mineral 75 |
| **22** | Mineral fertilizer equivalent to 50% of the dose | Mineral 50 |
| **23** | Molasses vinasse + concentrated broth at 30% of TSS + complement | Mixed |
| **24** | Concentrated molasses vinasse at 30% of TSS + complement | Molasses |
| **25** | Concentrated broth vinasse at 30% of TSS + complement | Pure |

* Reference values - 100%: 50, 100 and 100kg.ha-1 of N, P2O5 and K2O, respectively, this formulation adopted for being the most representative and standard in planting sugar cane in Mills in the Center-South of Brazil. In treatments $T_{23}$, $T_{24}$ and $T_{25}$, complementation was made in order to match the quantities of nitrogen, phosphorus and potassium applied in Treatment 20 ($T_{20}$).

The concentrated vinasse is derived from water evaporation process by the TASTE technology (*Thermally Accelerated Short Time Evaporation system*) (GURGEL, 2012). Vinasse of treatments came from three origins: (i) Mixed - vinasse from sugar and ethanol plant; (ii) Molasses - vinasse from a sugar mill; (iii) Broth - vinasse from an ethanol plant. Treatments took as a basis for comparison the amounts of N, P and K from the mineral fertilizer 100, 75 and 50%. Treatments of concentrated vinasse with 30% total soluble solids (TSS 30 = 22 °Brix, vinasse concentrated ± 10 times) and 45% of total soluble solids (TSS 45 = 55 °Brix vinasse concentrated ± 15 times) had the same source of (i) (ii) and (iii), and were also supplemented with chemical nutrients, as well as the BIOFOM treatments with 30% and 45% of total soluble solids.

BIOFOM preparation followed the method proposed by GURGEL (2009a, b), according to the following proportions: 10.7 (filter cake): 9.8 (vinasse with 30 or 45% of TSS): 5.0 (additives): 3.0 (molasses): 2.4 (ash): 1.5 (soot): 1.7 (urea): 1.0 (KCl) (by weight). Fertilizer granulation was made in dispersing discs driven by a 3 hp engine and 1710-rpm rotation, in which a reducer was installed to decrease disc rotation to 35 rpm. First, the quantified mixture of dry filter cake + boiler ashes + chimney soot was placed on the disc, and then concentrated vinasse containing 30 or 45% soluble solids was sprinkled, depending on the treatment. Together with the byproducts, three additives were added (polymer resin and humectant), which were responsible for stability of the final granules. Granule hardness of around 2.0 $kgf.cm^{-2}$ was expected for this method and final bead humidity near 8%, considering that the moisture removed in the dryer for storage ranged between 30 and 40%.

Once prepared with pure broth, molasses and mixed broth, the BIOFOM was characterized by physical-chemical analysis, performed at the Mineral Plant Nutrition Laboratory of the "Luiz de Queiroz" College of Agriculture, University of São Paulo.

The amounts of urea, total soluble solids and potassium chloride in the different treatments of BIOFOM and vinasse are described in Table 2.

TABLE 2. Amounts of urea, total soluble solids (ST) and potassium chloride (KCl) in the different treatments of BIOFOM and vinasse, in g $plot^{-1}$.

| Treatments | Source | BIOFOM | | | Vinasse | | |
|---|---|---|---|---|---|---|---|
| | | Urea | TSS | KCl | Urea | TSS | KCl |
| 1 Control | Limestone | - | - | - | - | - | - |
| 2 Mixed 30-50 | Limestone+BIOFOM | 0.981 | 0.538 | 0.780 | - | - | - |
| 3 Mixed 30-75 | Limestone+BIOFOM | 1.472 | 0.807 | 1.170 | - | - | - |
| 4 Mixed 30-100 | Limestone+BIOFOM | 1.963 | 1.077 | 1.560 | - | - | - |
| 5 Mixed 45-50 | Limestone+BIOFOM | 0.894 | 0.544 | 0.780 | - | - | - |
| 6 Mixed 45-75 | Limestone+BIOFOM | 1.340 | 0.816 | 1.170 | - | - | - |
| 7 Mixed 45-100 | Limestone+BIOFOM | 1.787 | 1.088 | 1.560 | - | - | - |
| 8 Molasses 30-50 | Limestone+BIOFOM | 0.432 | 0.439 | 0.780 | - | - | - |
| 9 Molasses 30-75 | Limestone+BIOFOM | 0.648 | 0.658 | 1.170 | - | - | - |
| 10 Molasses 30-100 | Limestone+BIOFOM | 0.864 | 0.878 | 1.560 | - | - | - |
| 11 Molasses 45-50 | Limestone+BIOFOM | 0.709 | 0.481 | 0.780 | - | - | - |
| 12 Molasses 45-75 | Limestone+BIOFOM | 1.064 | 0.722 | 1.170 | - | - | - |
| 13 Molasses 45-100 | Limestone+BIOFOM | 1.418 | 0.963 | 1.560 | - | - | - |
| 14 Pure 30-50 | Limestone+BIOFOM | 0.657 | 0.496 | 0.780 | - | - | - |
| 15 Pure 30-75 | Limestone+BIOFOM | 0.985 | 0.744 | 1.170 | - | - | - |
| 16 Pure 30-100 | Limestone+BIOFOM | 1.314 | 0.993 | 1.560 | - | - | - |
| 17 Pure 45-50 | Limestone+BIOFOM | 0.958 | 0.630 | 0.780 | - | - | - |
| 18 Pure 45-75 | Limestone+BIOFOM | 1.436 | 0.945 | 1.170 | - | - | - |
| 19 Pure 45-100 | Limestone+BIOFOM | 1.915 | 1.260 | 1.560 | - | - | - |
| 20 Mineral 100 | Limestone+4-20-20 | - | - | - | 0.411 | 0.813 | 0.644 |
| 21 Mineral 75 | Limestone+4-20-20 | - | - | - | 0.308 | 0.610 | 0.483 |
| 22 Mineral 50 | Limestone+4-20-20 | - | - | - | 0.206 | 0.407 | 0.322 |
| 23 Mixed | Limestone+MV[1]+MC[2] | - | - | - | 0.411 | 0.813 | 0.644 |
| 24 Molasses | Limestone+molasses+MC[2] | - | - | - | 0.411 | 0.813 | 0.644 |
| 25 Pure | Limestone+CP[3]+MC[2] | - | - | - | 0.411 | 0.813 | 0.644 |

[1] MV: Mixed vinasse.
[2] MC: Mineral complement corresponding to dose 100 of the mineral fertilizer
[3] Pure broth.

BIOFOM pots at dose 100 for the respective sources (mixed, molasses and broth) and concentrations (30% and 45% TSS) were, respectively, 19.498 g, 20.942 g, 15.180 g, 19.168 g, 21.040 and g 22.561 g of product per pot. The pots at doses 75 and 50 were given the above mentioned percentage quantities. The pots with mixed vinasse ($T_{23}$), molasses ($T_{24}$) and broth ($T_{25}$) each received a total of 0.644 g KCl, and for the first two cases, 0.277g and for the third case, 0.290 g of KCl equivalent as vinasse. As for the triple superphosphate (TSP), these treatments received in total per pot 0.813 g, with 0.019 g, 0.024 g 0,051g the equivalent amounts of vinasse. The same was true for urea, whose total dose per pot, $T_{23}$, $T_{24}$ and $T_{25}$, corresponded to 0.411 g, however, from this total, 0.048 g, 0.057 g and 0.087g corresponded to the equivalent amounts in vinasse.

Soil used in the experiment was removed from the first 25 cm surface Red-Yellow Ultisol medium texture (more than 25% clay in the B horizon), with the chemical characteristics given by soil analysis of the Soil Laboratory from the "Luiz de Queiroz" College of Agriculture, University of São Paulo. These analysis results were used to calculate the amount of dolomite limestone added to the soil to correct it.

Each pot contained 2.5 liter capacity, to which 2 kg of soil was added (with density of approximately 1.3 kg $L^{-1}$) and limestone corresponding to 0.625 g of $CaCO_3$ and 0.625g of MgO. BIOFOM granules and fertilizer for each treatment were homogenized with the soil from the bottom half of the pot and then supplemented with soil in the upper half. After liming and fertilizing, aiming at accelerating the effect of limestone, the pots were kept at water pot capacity (CASAROLI & VAN LIER, 2008) for seven days. Soil within pots was saturated with water in a recipient until saturation by capillary action was reached, what occurred after two days. Immediately after, they were covered with plastic film to prevent evaporation and placed to drain freely, weighing the mass after a period superior to 24 hours. From the gravimetric method (GARDNER, 1986), the values of water content in the soil were obtained. Then two corn seeds were sown per pot, using the Dow-2B-710 corn variety, whose emergence occurred uniformly in three days. After 8 days from sowing, thinning was performed leaving only one plant per pot.

Pot irrigation after the incubation period was carried out daily and irrigation quantification was performed with the gravimetric method mentioned above.

At 50 days after emergence, samples were taken and results evaluated with respect to the following variables leaf area (LA), by leaf area integrator LI-Cor® model LI 3100; shoot and root dry mass (SDM and RDM), by drying in an oven with air-ventilation at 65 °C for 48 hours. Macro and micronutrients were measured in plant shoot. Thus, the dry plant material was weighed and ground in Willey type mill and sampled to quantify macro and micronutrients, as described in MALAVOLTA et al., (1997).

Differences among treatments was performed by Tukey test (significance level at 5% probability). Statistical analysis was performed using SAS 9.2 software (Statistical Analysis System).

## RESULTS AND DISCUSSION

In relation to chemical fertilizer, the BIOFOM formulated presents similar particle size, but its production cost is shared with other processes such as production of sugar, ethanol and electricity. Compared to natural vinasse, the BIOFOM has no odor, has facilitated application because it is solid and grainy, and does not suffer percolation into the ground.

Vinasse can be originated from fermenting of different wort types: from molasses, from broth and mixed (broth + molasses). Vinasse from molasses has higher concentrations than broth and mixed have of the following items: soluble mineral waste, P, K, Ca, Mg, Mn, Zn and Na (Table 3).

TABLE 3. Physical-chemical analysis of the organomineral fertilizers (BIOFOM) used.

| Determinations | Pure broth | | Molasses | | Mixed broth | |
|---|---|---|---|---|---|---|
| | 30% TSS1 | 45% TSS | 30% TSS | 45% TSS | 30% TSS | 45% TSS |
| pH in CaCl2 (0.01 M) | 6.2 | 5.8 | 6.5 | 6.5 | 6.7 | 6.5 |
| Density (g.cm-3) | 0.52 | 0.58 | 0.50 | 0.52 | 0.54 | 0.57 |
| Humidity lost at 60-65°C (%) | 4.20 | 3.89 | 3.66 | 3.45 | 3.30 | 3.92 |
| Humidity lost between 65 and 110 °C (%) | 4.22 | 3.84 | 4.29 | 4.22 | 5.81 | 4.6 |
| Total humidity (%) | 8.42 | 7.73 | 7.95 | 7.76 | 9.01 | 8.52 |
| Total organic matter (combustion) (%) | 46.84 | 43.9 | 46.4 | 43.72 | 44.83 | 39.8 |
| Compost organic matter (%) | 45.44 | 41.45 | 41.55 | 41.6 | 41.73 | 36.25 |
| Organic matter resistant to composting (%) | 1.40 | 2.45 | 4.85 | 2.12 | 3.10 | 3.55 |
| Total carbon (organic and mineral) (%) | 26.02 | 24.39 | 25.78 | 24.29 | 24.91 | 22.11 |
| Organic carbon (%) | 25.24 | 23.03 | 23.08 | 21.11 | 23.19 | 20.14 |
| Total mineral waste (%) | 44.73 | 48.37 | 45.65 | 48.52 | 46.16 | 51.68 |
| Insoluble mineral waste (%) | 28.55 | 33.74 | 23.56 | 29.84 | 28.77 | 35.83 |
| Soluble mineral waste (%) | 16.18 | 14.63 | 22.09 | 18.68 | 17.39 | 15.85 |
| Total nitrogen (%) | 2.81 | 3.82 | 2.56 | 3.33 | 4.53 | 3.84 |
| Phosphorous (P2O5) total (%) | 2.17 | 2.57 | 2.66 | 2.31 | 2.54 | 2.39 |
| Potassium (K2O) total (%) | 4.30 | 4.01 | 5.96 | 4.72 | 4.64 | 4.32 |
| Calcium (Ca) total (%) | 2.17 | 2.50 | 2.81 | 2.56 | 2.45 | 2.42 |
| Magnesium (Mg) total (%) | 0.51 | 0.53 | 0.6 | 0.59 | 0.51 | 0.48 |
| Sulfur (S) total (%) | 0.28 | 0.28 | 0.40 | 0.58 | 0.31 | 0.27 |
| Ratio C/N (total C and total N) | 9/1 | 16/1 | 10/1 | 7/1 | 5/1 | 6/1 |
| Ratio C/N (organic C and total N) | 9/1 | 15/1 | 9/1 | 7/1 | 5/1 | 5/1 |
| Total copper (Cu) (mg.kg-1) | 36 | 41 | 38 | 39 | 51 | 36 |
| Total manganese (Mn) (mg.kg-1) | 1013 | 1226 | 1322 | 1122 | 1154 | 1139 |
| Total Zinc (Zn) (mg.kg-1) | 167 | 213 | 224 | 183 | 208 | 197 |
| Total iron (Fe) (mg.kg-1) | 11665 | 13865 | 12022 | 11845 | 11738 | 12898 |
| Total boron (B) (mg.kg-1) | 2 | 2 | 2 | 2 | 2 | 2 |
| Total sodium (Na) (mg.kg-1) | 1769 | 1343 | 2693 | 2408 | 1681 | 1486 |
| Hardness (kgf.cm-2) | 1.28 | 1.19 | 0.96 | 1.43 | 1.54 | 1.44 |

[1] TSS: total soluble solids.

For the variables in Table 4, the leaf area (LA) values had coefficient of variation of 12.47% and significant minimum deviation of 879.2 $cm^2$ $plant^{-1}$. In the dry weight of plant shoot (SDM), the results showed coefficient of variation of 7.97% and significant minimum deviation of 5.81 g $plant^{-1}$, and regarding the dry weight of roots (RDM), the coefficient of variation was of 7.87% and the significant minimum deviation of 1.92 g $plant^{-1}$.

TABLE 4. Leaf area (LA, $cm^2$ $plant^{-1}$), dry material mass of the corn plants aerial part (SDM, g $plant^{-1}$), mass of dry material from the roots of corn plants (RDM, g $plant^{-1}$).

| | Treatment | LA | SDM | RDM |
|---|---|---|---|---|
| 1 | Control | 546.1 F | 3.27 H | 8.25 C |
| 2 | Mixed - 30-50 | 2781.6 CDE | 14.52 BCDEF | 8.72 BC |
| 3 | Mixed - 30-75 | 2498.8 CDE | 9.92 FG | 8.86 ABC |
| 4 | Mixed - 30-100 | 2113.6 DE | 5.76 GH | 8.10 C |
| 5 | Mixed - 45-50 | 2759.0 CDE | 13.31 DEF | 8.98 ABC |
| 6 | Mixed - 45-75 | 2752.5 CDE | 12.12 EF | 8.67 ABC |
| 7 | Mixed - 45-100 | 2361.1 DE | 9.55 FG | 8.50 ABC |
| 8 | Molasses - 30-50 | 1961.9 E | 15.35 ABCDEF | 10.42 A |
| 9 | Molasses - 30-75 | 2293.0 DE | 15.83 ABCDE | 9.31 ABC |
| 10 | Molasses - 30-100 | 2653.7 CDE | 15.92 ABCDE | 10.22 AB |
| 11 | Molasses - 45-50 | 2767.3 CDE | 13.89 CDEF | 9.14 ABC |
| 12 | Molasses - 45-75 | 2675.2 CDE | 13.77 CDEF | 8.39 BC |
| 13 | Molasses - 45-100 | 2902.5 BCD | 13.26 DEF | 8.33 BC |
| 14 | Pure - 30-50 | 2098.8 DE | 14.36 BCDEF | 8.91 ABC |
| 15 | Pure - 30-75 | 2490.3 CDE | 15.30 ABCDEF | 9.92 ABC |
| 16 | Pure - 30-100 | 2848.8 CD | 15.15 ABCDEF | 9.19 ABC |
| 17 | Pure - 45-50 | 2450.7 DE | 15.32 ABCDEF | 9.79 ABC |
| 18 | Pure - 45-75 | 2701.8 CDE | 16.10 ABCDE | 8.55 ABC |
| 19 | Pure - 45-100 | 2870.1 CD | 14.94 ABCDEF | 9.07 ABC |
| 20 | Mineral - 100 | 3771.0 AB | 20.42 A | 9.14 ABC |
| 21 | Mineral - 75 | 3891.3 A | 19.51 ABC | 9.64 ABC |
| 22 | Mineral - 50 | 3361.5 ABC | 17.68 ABCDE | 9.38 ABC |
| 23 | Mixed | 2812.4 CDE | 19.79 AB | 8.66 ABC |
| 24 | Molasses | 2527.8 CDE | 18.72 ABCD | 9.27 ABC |
| 25 | Pure | 2616.3 CDE | 18.36 ABCD | 9.81 ABC |

* Same letters indicate that the means do not differ significantly to the 5% level of significance by the Tukey test.

As for the leaf area, the three doses of mineral fertilizer ($T_{20}$, $T_{21}$ and $T_{22}$) showed no significant differences among them, and treatments 20 and 22 showed no significant differences of molasses vinasse BIOFOM 45 at dose 100 ($T_{13}$). Dose 50 of the mineral fertilizer ($T_{22}$) showed no significant differences from doses 50 and 75 of mixed vinasse BIOFOM 30 and 45 ($T_2$, $T_3$, $T_5$ and $T_6$), from dose 100 of molasses BIOFOM 30 ($T_{10}$) and from dose 3 of molasses BIOFOM 45 ($T_{11}$, $T_{12}$ and $T_{13}$), from doses 75 and 100 of broth vinasse BIOFOM 30 and 45 ($T_{15}$, $T_{16}$, $T_{18}$ and $T_{19}$) and from the three concentrated vinasse at 30% total solids, with the mineral supplementation corresponding to dose 100 of the mineral fertilizer ($T_{23}$, $T_{24}$ and $T_{25}$). For this parameter, the Control differed significantly from all other treatments.

BIOFOM performance, of molasses vinasse concentrated at 30% total solids at any dose, can be understood as satisfactory when compared to the treatment of mineral fertilizers 100 (S20). In the same way, it can be noted for BIOFOM from pure broth vinasse concentrated 30% or 45% TSS, except for $T_{14}$, concentrated at 30% TSS, which has a dose of 50% of the dose of the mineral fertilizer.

For plant shoot dry material, the three doses of mineral fertilizer ($T_{20}$, $T_{21}$ and $T_{22}$) showed no significant differences among them or from the three doses of broth vinasse BIOFOM 30 and 45 ($T_{14}$ to $T_{19}$), from the three doses of molasses vinasse BIOFOM 30 ($T_8$, $T_9$ and $T_{10}$) and from the three vinasse concentrated at 30% total solids, with mineral complementation corresponding to dose 100 of the mineral fertilizer ($T_{23}$, $T_{24}$ and $T_{25}$).

The fact that the treatments with the application of mineral fertilizer have promoted larger leaf area and dry matter mass of plant shoot shows that part of the nutrients in BIOFOM was not available until 45 days after application. This is an advantage when working in an open system, where leaching of mobile nutrients may occur. In this experiment, once it is a closed system (vessels), this loss did not occur; leading treatments in which fertilization with mineral fertilizers was made to have higher efficiency, which will certainly not occur in the field.

For root dry mass, dose 50 of molasses vinasse BIOFOM 30 ($T_8$) only showed significant difference from molasses vinasse BIOFOM 45 at doses 75 and 100 ($T_{12}$ and $T_{13}$), from the mixed vinasse BIOFOM 30 at doses 50 and 100 ($T_2$ and $T_4$) and from the control. For this parameter, the witness only differed from treatments of mixed vinasse BIOFOM 30, at doses 100 and 50 ($T_8$ and $T_{10}$).

Table 5 presents the average values of four replicates of the main macronutrients accumulation in the shoots of maize plants.

TABLE 5 - Accumulation of macronutrients (mg plant-1) in aerial part of corn plants.

| Treatments | N | P | K | Ca | Mg | S |
|---|---|---|---|---|---|---|
| 1 Control | 35.44 D | 2.82 I | 33.56 D | 12.61 E | 25.57 E | 2.96 D |
| 2 Mixed 30-50 | 195.68 C | 20.54DEFGH | 357.83 BC | 44.55 BCD | 65.15 AB | 15.71 BC |
| 3 Mixed 30-75 | 226.12 C | 24.79 CDEFGH | 369.62 BC | 35.98 CDE | 38.18 BCDE | 14.30 BC |
| 4 Mixed 30-100 | 161.47 CD | 11.91 HI | 236.12 CD | 22.19 DE | 28.34 DE | 11.17 CD |
| 5 Mixed 45-50 | 214.73 C | 18.63 EFGHI | 365.16 BC | 45.00 BCD | 57.03 ABC | 14.94 BC |
| 6 Mixed 45-75 | 236.80 C | 23.98 CDEFGH | 424.17 ABC | 36.25 CDE | 46.58 ABCDE | 15.75 BC |
| 7 Mixed 45-100 | 222.01 C | 23.37 CDEFGH | 362.87 BC | 31.22 CDE | 31.87 CDE | 14.84 BC |
| 8 Molasses 30-50 | 158.96 CD | 18.00 EFGHI | 348.11 BC | 42.15 BCD | 45.28 ABCDE | 10.30 CD |
| 9 Molasses 30-75 | 190.44 C | 24.82 CDEFGH | 540.78 AB | 55.06 ABC | 51.17 ABCDE | 12.52 BCD |
| 10 Molasses 30-100 | 213.21 C | 25.98 CDEFGH | 608.35 AB | 55.03 ABC | 51.27 ABCDE | 16.95 ABC |
| 11 Molasses 45-50 | 190.52 C | 18.21 EFGHI | 366.50 BC | 47.34 BC | 46.50 ABCDE | 12.13 CD |
| 12 Molasses 45-75 | 197.61 C | 23.02 CDEFGH | 531.62 ABC | 49.72 ABC | 49.77 ABCDE | 15.14 BC |
| 13 Molasses 45-100 | 231.01C | 27.18 CDEFGH | 418.67 ABC | 51.42 ABC | 42.74 ABCDE | 16.91 ABC |
| 14 Pure 30-50 | 131.86 CD | 15.02 GHI | 314.73 BCD | 38.61 BCD | 49.04 ABCDE | 9.23 CD |
| 15 Pure 30-75 | 167.44 CD | 19.69 DEFGH | 432.04 ABC | 39.68 BCD | 51.90 ABCDE | 12.39 BCD |
| 16 Pure 30-100 | 223.77 C | 24.12 CDEFGH | 378.33 BC | 43.18 BCD | 43.58 ABCDE | 15.49 BC |
| 17 Pure 45-50 | 193.29 C | 17.01 FGHI | 350.47 BC | 36.09 CDE | 55.28 ABCD | 12.62 BCD |
| 18 Pure 45-75 | 231.84 C | 23.67 CDEFGH | 448.34 ABC | 38.10 BCD | 58.36 ABC | 13.80 BC |
| 19 Pure 45-100 | 255.18 BC | 29.24 CDEFG | 468.91 ABC | 41.07 BCD | 51.69 ABCDE | 17.24 ABC |
| 20 Mineral 100 | 490.73 A | 71.43 A | 702.79 A | 73.20 A | 60.66 AB | 26.06 A |
| 21 Mineral 75 | 369.68 AB | 51.91 B | 613.54 AB | 60.44 AB | 61.77 AB | 22.38 AB |
| 22 Mineral 50 | 245.05 BC | 35.17 CD | 396.95 BC | 47.13 BC | 70.22 A | 14.38 BC |
| 23 Mixed | 226.06 C | 38.20 BC | 503.61 ABC | 46.50 BC | 55.54 ABCD | 17.69 ABC |
| 24 Molasses | 184.84 C | 33.23 CDE | 457.79 ABC | 38.91 BCD | 55.12 ABCD | 13.87 BC |
| 25 Pure | 185.88 C | 31.33 CDEF | 442.25 ABC | 48.73 BC | 59.94 ABC | 14.26 BC |

* Same letters indicate that the means do not differ significantly at the 5% level of significance by the Tukey test.

**Nitrogen (N):** The results showed a coefficient of variation of 22.82% and significant minimum deviation of 132.08 mg $plant^{-1}$. Dose of 100 of the mineral fertilizer ($T_{20}$) was not significantly different from dose 75 ($T_{21}$), nor the latter from dose 50 ($T_{22}$) and from dose 100 of the broth vinasse BIOFOM 45 ($T_{19}$). All other treatments of BIOFOM and concentrated and complemented vinasse did not differ significantly from $T_{22}$. Mass productivity of the aerial part of the Control treatment was significantly lower than all other treatments due to the low supply of nutrients.

**Phosphorus (P):** The results for this nutrient showed a coefficient of variation of 22.58%, and a significant minimum deviation of 15.87 mg $plant^{-1.}$ Dose 100 of the mineral fertilizer ($T_{20}$) showed significant difference from dose 75 ($T_{21}$) and this, in turn, did not differ significantly from vinasse molasses + broth, supplemented with mineral fertilizer ($T_{23}$). All BIOFOM treatments and other complemented vinasse did not differ significantly from dose 50 of the mineral fertilizer ($T_{22}$), except for the treatments of broth vinasse and molasses vinasse BIOFOM 30 and 45 at dose 50 ($T_8$, $T_{11}$, $T_{14}$ and $T_{17}$), the molasses vinasse + broth 30 at dose 100 ($T_4$) and the molasses vinasse + broth 45 at dose 50 ($T_5$) which did not differ significantly from the Control. The fact that the treatments with doses 100 and 75 of the mineral fertilizer ($T_{20}$ and $T_{21}$) promoted greater phosphorus accumulation in plant shoot shows that part of the phosphorus present in the BIOFOM was not available until 45 days after application.

**Potassium (K):** The results showed a coefficient of variation of 26.82%, and a minimum significant deviation of 302.22 mg plant$^{-1}$. Dose 100 of the mineral fertilizer ($T_{20}$) was not significantly different from dose 75 ($T_{21}$), from the three concentrated and supplemented vinasse ($T_{23}$, $T_{24}$ and $T_{25}$) and from broth vinasse BIOFOM 45, at doses 75 and 100 ($T_{18}$ and $T_{19}$), from broth vinasse BIOFOM 30 at dose 75 ($T_{15}$), from molasses vinasse BIOFOM 30 and 45, at doses 75 and 100 ($T_9$, $T_{10}$, $T_{12}$ and $T_{13}$), and from mixed vinasse BIOFOM 45, at dose 75 ($T_6$). The control, without fertilizer application, resulted in the lowest values of K accumulation in the aerial part, not differing only from treatments Mixed 30-100 ($T_4$) and Pure 30-50 ($T_{14}$), but differing from the others.

**Calcium (Ca):** The results showed coefficient of variation of 22.75%, and a minimum significant deviation of 24.12 mg plant$^{-1}$. Dose 100 of the mineral fertilizer ($T_{20}$) was not significantly different from dose 75 ($T_{21}$) and from molasses vinasse BIOFOM 30 and 45 at doses 75 and 100 ($T_9$, $T_{10}$, $T_{12}$ and $T_{13}$). Dose 75 of the mineral fertilizer ($T_{21}$) showed a significant difference from broth vinasse BIOFOM 30 at dose 50 ($T_{14}$), from mixed vinasse BIOFOM 30 and 45 at doses 75 and 100 ($T_3$, $T_4$, $T_6$ and $T_7$) and broth vinasse BIOFOM 45 at dose 50 ($T_{17}$). Control did not differ only from treatments $T_3$, $T_4$, $T_6$, $T_7$ and $T_{17}$. The fact that the treatments with the application of mineral fertilizer at doses 100 and 75 promoted higher calcium accumulation in plant shoot is due to the greater availability of N, P and K to the plant in the first 45 days, which did not occur in the same magnitude with plants receiving complemented vinasse and BIOFOM.

**Magnesium (Mg):** For Mg, the results showed a coefficient of variation of 20.86%, and a minimum significant deviation of 28.12 mg plant$^{-1}$. All three doses of mineral fertilizer ($T_{20}$, $T_{21}$ and $T_{22}$) showed no significant difference among them and against BIOFOM treatments, except the mixed vinasse 30 at dose 100 ($T_4$), and the mixed vinasse 45 at dose 100 ($T_7$). The control differed significantly from the three complemented vinasse ($T_{23}$ to $T_{25}$), from the three doses of mineral fertilizer, from broth vinasse BIOFOM 45 at doses 50 and 75 ($T_{17}$ and $T_{18}$) and from mixed vinasse BIOFOM 30 and 45 at dose 50 ($T_2$ and $T_5$).

**Sulfur (S):** For this parameter, the results showed a coefficient of variation of 25.64%, and a minimum significant deviation of 10.02 mg plant$^{-1}$. Doses 100 and 75 of the mineral fertilizer ($T_{20}$ and $T_{21}$) showed no significant difference between them and the complemented mixed vinasse ($T_{23}$), the broth vinasse BIOFOM 45 at dose 100 ($T_{19}$) and the molasses vinasse BIOFOM 45 and 30 at dose 100 ($T_{10}$ and $T_{13}$). Dose 75 of the mineral fertilizer ($T_{21}$) showed a significant difference from the Control and from broth vinasse BIOFOM 30 at dose 50 ($T_{14}$), from molasses vinasse 45 and 30 at dose 50 ($T_8$ and $T_{11}$) and from mixed vinasse 30 at dose 100 ($T_4$). The Control differed significantly from the three complemented vinasse ($T_{23}$ to $T_{25}$), from the three doses of mineral fertilizer ($T_{20}$ to $T_{22}$), from the broth vinasse and molasses vinasse BIOFOM 45 at doses 100 and 75 ($T_{12}$, $T_{13}$, $T_{18}$ and $T_{19}$), from the molasses and broth vinasse BIOFOM 30 at dose 100 ($T_{10}$ and $T_{16}$), from the mixed vinasse BIOFOM 45 at the three doses ($T_5$ to $T_7$) and from molasses vinasse BIOFOM + broth 30 at doses 75 and 50 ($T_2$ and $T_3$).

In general, it was noted that treatments $T_{20}$ and $T_{21}$, with the application of doses 100 and 75 of the mineral fertilizer, promoted greater accumulation of N, P and K in plant shoot, showing that part of these nutrients in the BIOFOM was not available within 45 days after application - which is an advantage when working in an open system where there is leaching of mobile nutrients in the soil. In the experiment, because it is a closed system (pots), this loss did not occur, leading treatments where the fertilization with mineral fertilizers was performed to present a slightly higher efficiency, which should not occur in the field.

For sugar cane, whose cycle is from 12 to 18 months, long enough for the rest of the N, P, K of the BIOFOM to be made available in an open system, BIOFOM behavior can be expected to be similar, or even better than those with mineral fertilizer.

Table 6 shows the experimental results regarding the accumulation of the main micronutrients within corn plant shoot.

TABLE 6 - Accumulation of micronutrients (μg plant-1) in aerial part of corn plants.

| Treatment | B | Cu | Fe | Mn | Zn |
|---|---|---|---|---|---|
| 1 Control | 77.15 B | 18.87 D | 402.14 E | 937.57 F | 118.48 E |
| 2 Mixed 30-50 | 306.94 AB | 100.14 ABC | 1373.92 ABCDE | 9824.32 CDE | 539.36 ABCD |
| 3 Mixed 30-75 | 275.90 AB | 87.51 BCD | 1151.89 BCDE | 8199.16 CDEF | 408.88 CD |
| 4 Mixed 30-100 | 166.46 AB | 47.25 CD | 787.82 DE | 5455.51 EF | 247.99 DE |
| 5 Mixed 45-50 | 350.54 AB | 83.22 BCD | 1408.22 ABCD | 9135.06 CDE | 524.21 ABCD |
| 6 Mixed 45-75 | 377.47 AB | 94.32 ABC | 1353.43 ABCDE | 8104.59 CDEF | 447.78 BCD |
| 7 Mixed 45-100 | 332.81 AB | 78.21 CD | 940.30 CDE | 6879.79 EF | 349.25 CDE |
| 8 Molasses 30-50 | 156.84 AB | 75.81 CD | 1670.96 ABCD | 9345.58 CDE | 480.45 ABCD |
| 9 Molasses 30-75 | 353.74 AB | 87.22 BCD | 1645.13 ABCD | 6532.62 EF | 447.14 BCD |
| 10 Molasses 30-100 | 404.43 AB | 112.30 ABC | 1719.73 ABCD | 7410.00 DEF | 453.77 BCD |
| 11 Molasses 45-50 | 266.01 AB | 73.95 CD | 1419.51 ABCD | 5427.56 EF | 525.57 ABCD |
| 12 Molasses 45-75 | 375.91 AB | 89.78 ABCD | 1705.98 ABCD | 7681.92 DEF | 520.17 ABCD |
| 13 Molasses 45-100 | 222.42 AB | 95.02 ABC | 1463.14 ABCD | 9070.85 CDE | 542.96 ABCD |
| 14 Pure 30-50 | 481.48 AB | 71.66 CD | 1567.92 ABCD | 6635.32 EF | 381.28 CDE |
| 15 Pure 30-75 | 305.24 AB | 77.13 CD | 1427.05 ABCD | 7774.58 DEF | 450.96 BCD |
| 16 Pure 30-100 | 383.57 AB | 110.75 ABC | 1579.58 ABCD | 9525.57 CDE | 455.36 BCD |
| 17 Pure 45-50 | 214.13 AB | 80.89 BCD | 1459.13 ABCD | 8904.68 CDE | 422.29 BCD |
| 18 Pure 45-75 | 467.17 AB | 82.80 BCD | 1383.64 ABCDE | 10259.91 CDE | 453.20 BCD |
| 19 Pure 45-100 | 223.48 AB | 109.58 ABC | 1240.20 ABCDE | 9442.37 CDE | 498.91 ABCD |
| 20 Mineral 100 | 511.12 AB | 159.47 A | 2230.22 A | 17813.58 AB | 775.77 A |
| 21 Mineral 75 | 379.33 AB | 151.14 AB | 2104.15 AB | 20910.64 A | 710.36 AB |
| 22 Mineral 50 | 473.87 AB | 106.31 ABC | 1846.04 ABC | 15425.94 ABC | 579.78 ABC |
| 23 Compl. Mixed | 447.70 AB | 112.22 ABC | 1905.89 ABC | 14689.61 ABCD | 558.89 ABC |
| 24 Compl. Molasses | 456.87 AB | 91.57 ABC | 1615.97 ABCD | 12105.27 CDE | 505.65 ABCD |
| 25 Compl. Pure | 539.51 A | 112.23 ABC | 1509.33 ABCD | 9363.25 CDE | 506.33 ABCD |

* Averages in each row, followed by the same letters, do not differ significantly at the 5% level of significance by the Tukey test.
* Médias, em cada coluna, seguidas de letras iguais não diferem significativamente a 5% de probabilidade pelo teste de Tukey.

**Boron (B):** For this micronutrient, the results showed a coefficient of variation of 48.10%, accumulating variations of concentrations of B and dry material, and a minimum significant deviation of 442.54 μg plant$^{-1}$. Control significantly differed only from the complemented broth vinasse ($T_{25}$), and no other treatments differed from each other due to the high coefficient of variation of B concentrations within corn plant shoot and to the high value of the minimum significant deviation.

**Copper (Cu):** The results showed a coefficient of variation of 28.82%, and a minimum significant deviation of 71.61 μg plant$^{-1}$. All three doses of mineral fertilizer ($T_{20}$ to $T_{22}$) showed no significant difference among them or against the three supplemented vinasse ($T_{23}$ to $T_{25}$), broth vinasse BIOFOM 30 and 45 at dose 100 ($T_{16}$ and $T_{19}$), of molasses vinasse 45 at doses 75 and 100 ($T_{12}$ and $T_{13}$), of molasses vinasse 30 at dose 100 ($T_{10}$), of mixed vinasse 45 at dose 75 ($T_6$) and of mixed vinasse 30 at dose 50 ($T_2$). Control differed significantly from the three complemented vinasse ($T_{23}$ to $T_{25}$), from the three doses of mineral fertilizer, from the broth vinasse BIOFOM 30 and 45 at dose 100 ($T_{16}$ and $T_{19}$), from the molasses vinasse BIOFOM 30 and 45 at dose 100 ($T_{10}$ and $T_{13}$), from the mixed vinasse BIOFOM 45 at dose 75 ($T_6$) and from mixed vinasse 30 at a dose 50 ($T_2$).

**Iron (Fe):** For this nutrient, the results showed coefficient of variation of 25.04%, and a minimum significant deviation of 994.44 μg plant$^{-1}$. All three doses of mineral fertilizer showed no significant differences among them ($T_{20}$ to $T_{22}$). Treatment $T_{21}$ differed only from the treatment of molasses vinasse BIOFOM + broth 30 at dose 100 ($T_4$), from the molasses vinasse BIOFOM treatment + broth 45 at dose 100 ($T_7$) and Control. Control did not differ from treatments 2, 3, 4, 6, 7, 18 and 19.

**Manganese (Mn):** In the case of Mn, the results showed coefficient of variation of 29.31%, and a minimum significant deviation of 7470 μg plant$^{-1}$. All three doses of mineral fertilizer showed no significant difference among them and the complemented mixed vinasse ($T_{23}$). Dose 50 of the mineral fertilizer ($T_{22}$) showed a significant difference from the broth vinasse BIOFOM 30 at doses 50 and 75 ($T_{14}$ and $T_{15}$), from molasses vinasse BIOFOM 45 at doses 50 e75 ($T_{11}$ and $T_{12}$) and from molasses 30 at doses 75 and 100 ($T_9$ and $T_{10}$), from mixed vinasse 30 and 45 at dose 100 ($T_4$ and $T_7$) and from the Control. This, in turn, did not differ significantly, in addition to those which differed from dose 50 of mineral fertilizer, from the mixed vinasse BIOFOM 30 and 45 at dose 75 ($T_3$ and $T_6$).

**Zinc (Zn):** For this parameter, the results showed coefficient of variation of 23.07%, and a minimum significant deviation of 295.34 μg plant$^{-1}$. All three doses of mineral fertilizer ($T_{20}$ to $T_{22}$) showed no significant difference among them or from the three supplemented vinasse ($T_{23}$ to $T_{25}$), from broth vinasse BIOFOM 45 at dose 100 ($T_{19}$), from molasses vinasse BIOFOM 45 in three doses ($T_{11}$ to T13), from molasses vinasse BIOFOM 30 at dose 50 ($T_8$), from mixed vinasse 30 and 45 at dose 50 ($T_2$ and $T_5$). Control did not differ significantly from the broth vinasse BIOFOM 30 at dose 50 ($T_{14}$), from mixed vinasse 30 and 45 at dose 100 ($T_4$ and $T_7$).

Organic matter applied via BIOFOM promotes the improvement of soil physicochemical properties, cation exchange capacity and porosity, which favors the nutrient absorption and reduce losses caused by leaching (GURGEL, 2012).

After 60 days from corn planting, it was observed that the BIOFOM was attached to the roots due to its fertilizer condition, wherein the organic matter provides the gradual release of nutrients.

FIGURE 1. BIOFOM granules adhered to roots of corn plant.

The BIOFOM reduces the generation of waste from the sugar and ethanol industry, using the residues rationally to produce organomineral fertilizers.

Thus, BIOFOM is a sustainable solution, and complies with applicable environmental laws. Ordinances, MINTER nº 323 of 1978, prohibit the release of vinasse in surface watercourses. Resolutions from CONAMA (National Environment Council), 0002 of 1984 and 0001 of 1986, determine, respectively, the study and development of standards to control effluent from ethanol distilleries and the obligation of performing EIA (Environmental Impact Studies) and RIMA (Report on Environmental Impact) for new plants or expansions of existing ones. Law nº 6134/ 1988 (art. 5) of the State of São Paulo determines that waste from activities (industrial and others) must not pollute groundwater. In this sense, waste use benefits the environment because all residue produced within sugarcane processing can be transformed into BIOFOM, minimizing the risk of groundwater and soil contamination by washing wastes.

## CONCLUSIONS

Considering soil type and crop to be grown, we can conclude that BIOFOM can replace the use of mineral fertilizers, and the pure broth vinasse BIOFOM with 30% and 45% of total solids and the ones from molasses vinasse with 30% total solids achieved the same performance of the mineral fertilizers and of the three supplemented vinasse (mineral supplementation corresponding to dose 100 of the mineral fertilizer). Organomineral fertilizers (BIOFOM) from mixed vinasse with 30% and 45% total solids and the ones from molasses vinasse with 45% total solids, with adjustments in the amounts of the mineral fertilizer added, depending on the cropped plant, may have same performance as the mineral fertilizer and the three supplemented vinasse.

The use of BIOFOM, in the context of sugarcane industry, can reduce production costs, especially for the lower cost of mineral fertilizer, transportation, operations and infrastructure, given the elimination of individual application of vinasse, filter cake and ash.

The addition of mineral fertilizer enables the use of wastes from sugar and alcohol industry as a granulate organomineral fertilizer involving the concentration of vinasse, in addition to the aforementioned benefits, also provides the opportunity for reuse of evaporated water in the processes of recirculation and closing of circuits, allowing the minimization of water uptake by sugarcane agribusiness.

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