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Application of Sewage Sludge of Shrimp Farms as an Alternative to Organic Fertilizers in the Cultivation of Maize (*Zea mays* L) in the Area of Maracaibo Lake (Venezuela)

Katuisca Acosta[1*], Iris A. Jimenez-Pitre[2] and Geomar Molina-Bolivar[2]

[1]Agricultural Microbiology Laboratory. Faculty of Agronomy. University of Zulia; kacosta@fa.luz.edu.ve
[2]BIEMARC research group. University of La Guajira; gmolina@uniguajira.edu.co, iajimenez@uniguajira.edu.co

Abstract

Objective: The effect of residual sludge of industrial shrimp farming on the initial growth of maize is conducted. **Materials and Methods**: We used bags of 5 kg with polystirene surface horizon + mud-cattle manure (L+Mo). We used an experimental design totally at random with four treatments: T1: 0% (50 kg ha -1 CV + 0 ton.ha -1 L+ Mo + complete formula 14-14-14), T2: 2% (49 kg ha-1 HP+52 ton ha-1 L + Mo) T3: 4% (48 kg ha-1 CV ton.ha-1 139-141 Cromwell Road L+Mo) and T4: 6% (47 kg ha-1 CV+156 ton ha-1 L + Mo) and 10 repetitions. **Results**: Non-destructive variables were evaluated (plant height, number of sheeths, the stem thickness, average length of the leaves and average width of the leaves) using repeated measures in time with five weekly evaluations and destructive variables (leaf area, dry mass and air and root) using a 4x2 factorial, with 4 treatments and 2 evaluations (21 and 35 days after sowing). In the first evaluation (21 days after) no differences were observed between treatments; while for the second evaluation (35 days after) the T4 with the dose of 156 ton.ha-1L + MO showed the greatest growth of maize during under controlled conditions. **Applications**: The incorporation of sludge produced improvements in physical and chemical properties of the soil recipient.

Keywords: Cultivation *of Zea mays* L, Organic Fertilizers, Sewage Sludge, Shrimp Farms

1. Introduction

The treatment and final disposal of sludge generated by different companies in the food sector constitutes a serious problem of environmental impact, generating high costs of adaptation of the same to mitigate this effect[1]. The deposition of sludge in the channel of the pools of shrimp farming of many farms generates significant obstructions in the same, preventing the continuous flow of water, presenting therefore a problematic. In Venezuela is wasted, the potential for use and dispose of these sludges only as a residue: thus, increasing the amount of waste to dispose of in landfills, so frequently must be removed, becoming a waste of great environmental impact that must be resolved without generating unfavorable side effects to the ecosystem, and operating costs to businesses.

In this sense, one of the alternatives is the use and incorporation of this organic material from organic waste as well as practical and cost-effective options to revitalize the degraded soil. However, the industrial sludges can be beneficial as a soil amendment on agricultural lands, as well as remediation and revegetation projects, its application as an amendment to mud, either fresh or composted, has been proposed as a viable alternative to recycle nutrients from organic waste and to improve soil fertility to a lower level cost[2].

In this sense, it has been pointed out that the use as an amendment of mud has beneficial effect on the improve-

*Author for correspondence

ment of physical and chemical properties of agricultural soil, in terms of increases in the levels of organic matter, decreased the apparent density, better educated and aggregate stability, better moisture retention, increase in the size of pores, provides significant amounts of nitrogen and phosphorus that contributes to soil fertility and to reduce the consumption of chemical fertilizers[3,4]. As well as, also promotes soil microbial activity and reduces soil contamination[1].

However, along with the benefits of the use of sludge, consideration should also be given to the risks that represent these materials, since each material is different and may contain high concentrations of contaminants including heavy metals, dyes and pathogenic microorganisms, which can potentially be toxic to crops or for consumers of the products of the same, hence its use may not be indiscriminate without proper planning and supervision[5,6]. There is a need for proper management of this sludge generated, for the efficient operation of any installation of agri-food companies that use large amounts of water in the various internal production processes, such as the shrimp industry zuliana, which maintains permanent and fluent exchange of enormous quantities of water with the estuary Lake Maracaibo. So, in this study had to assess the effect of the application of residual sludge of the shrimp farm on the initial growth of maize crops.

2. Materials and Methods

Sludge samples were taken in the channel of the farm San Jose del Lago located in the municipality Cañada de Urdaneta Zulia state. We collected a sample composed of 3-4 sub-samples taken at the level of the entry of the four swimming pools to a depth of 0-20 cm. Once collected the sample was placed in plastic tanks for draining excess moisture and air dried for a period of 5 days and passed through a sieve with 2 mm, to homogenize the samples.

Subsequently, these mud samples were transported to the Laboratory of Microbiology of the Phytosanitary Technical Unit of the Faculty of Agronomy of the University of Zulia. There was a mud-mix organic matter (L + Mo) in relation 1:1, taking as a source of organic matter cattle manure, which was used in different doses, depending on the treatment assigned to each plant of each treatment which are 4 to 10 repetitions. Treatments were evaluated 4 mud-organic matter (L+Mo) (ton.ha^{-1}): T1: 0 ton.ha^{-1} (L+ MO) T2: 52 ton.ha^{-1} (L + MO) T3: 104 ton.ha^{-1} (L + MO) and T4: 156 ton.ha^{-1} (L + MO).

In bag of 5 kg is proceeded to sow 4 Dekalb seed corn 7088, tropical hybrid with yellow grain, high-performance. All plants were subjected to the same conditions of agronomic management with 3 weekly watering to applying 2 L per bag, keeping under controlled conditions in the house of cultivation of the Unit. The experiment was established through a completely randomized experimental design with four treatments. The experimental unit was represented by a plant of *Z. mays* established in Nursery Bag of 5 kg using as substrate the respective treatment of mixture of L+Mo. Non-destructive variables (plant height, number of leaves, the stem thickness, average length of the leaves, average width of the leaves) were analyzed following the methodology of repeated measurements with 5 evaluations (7, 14, 21, 28 and 35 days after the experiment) by adjusting polynomial models to estimate the effect of L+MO on initial growth.. Destructive variables (leaf area, dry mass and air and root) were analyzed using a factorial arrangement of treatments in 4x2 with treatments (T1, T2, T3 and T4) and evaluation (21 and 35 days of development of the crop) as factors in study, for those factors that are significant means tests will be carried out using the Tukey Test[7].

3. Result and Discussion

It was observed that all the treatments with sludge mixing application + organic matter, began their emergency procedure to 2-3 days of planting, reaching levels of germination in a 96- 98 %, which was a reliable indicator of the maturity of the biosolido in order to be applied to the soil, so it has been pointed out that the germination should be above 50% for considering that biosolids prepared does not produce effects of phytotoxicity negative effects on seedling, since during the period of germination occur numerous physiological processes in which the presence of phytotoxic elements, such as Cu, Ni and Zn, could interfere by altering the seed viability and normal development of The seedlings[8]. The effect was maintained during the period of initial growth of cultivation of *Z. mays* used in this essay, where there were no symptoms that could indicate any toxic effect in plants.

The data of initial growth of Z. mays were analyzed following the Methodology of Repeated Measurements

(MRT) by adjusting the structure of covariance with a composite model symmetrical and to estimate the fixed effect of treatments over time. Different models were adjusted by selecting the second order polynomial model $Y=\alpha + \beta X + \gamma X^2$, Where and represents the response variable; α, β and γ are the parameters to be estimated and X represents the time in days. In general, the response of the plant height (HP) to the treatments followed a quadratic trend being the model for the treatment T4 that estimates the greater heights of plant with values of 53.63 cm, followed by treatment T2 and T3, whose plants reached height of 44, 36 and 50.40 cm respectively, indicating a difference of 7 cm when compared with the treatment 1 who attained heights of 46.47 cm (Figure 1).

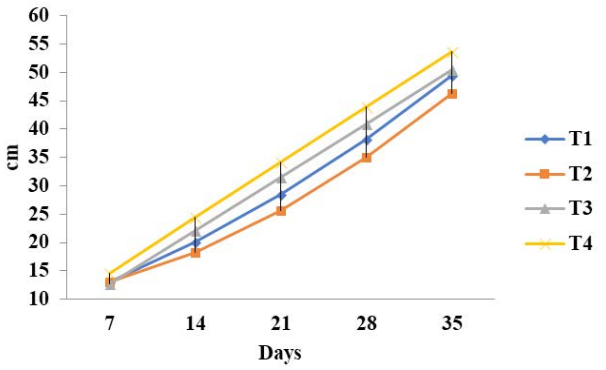

Figure 1. Effect of the application of different doses of sludge on the height of the plant during the initial growth of the cultivation of Z. mays.

The Number of Leaves (NL), appreciation was the same trend in the behavior for the previous variable. Where the highest values were achieved by plants for the treatment T4 with a total of 11 sheets with a mixture of mud+Mo of 156 ton ha^{-1} followed by plants of the treatments T3 and T2 with values of 9 to 10 leaves per plant, there is a difference of 2-3 sheets compared to plants that did not receive high-dose of mud. There has been a 18% increases in the number of sheets in the cultivation of maize, with doses of 45 tonnes per hectare of sewage sludge in comparison with plants without application of sewage sludge (Figure 2)[9].

With regard to the variable the stem thicknesses the treatments 3 and 4 are those who believe the highest values for this variable, achieved levels of 23.73 mm and 23 mm non-significant differences between them, while the treatments T2 and T1 showed values of 19.81 mm and 19.80 mm, observing a difference of 3.92 mm in relation to the treatment plants of the witness in comparison with the plants that received between 156 ton ha^{-1} and 104 ton ha^{-1} of the mixture mud+Mo. The increase of 60% in the stem thickness by applying dose of dry mud in relation of 6 - 8 mixed with sand washed in comparison with sludge composting plants that received in doses 50, 75 and 100 % (Figure 3)[10].

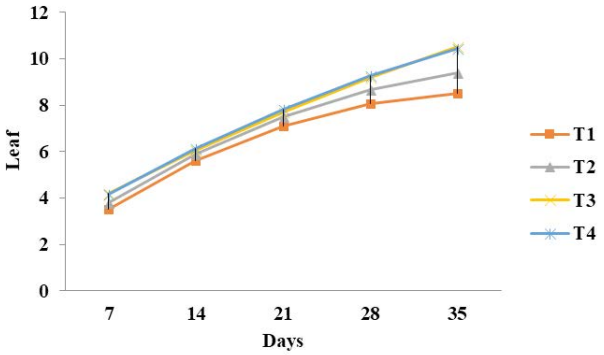

Figure 2. Effect of the application of different doses of sludge on the number of leaves during the initial growth of *Z. mays*.

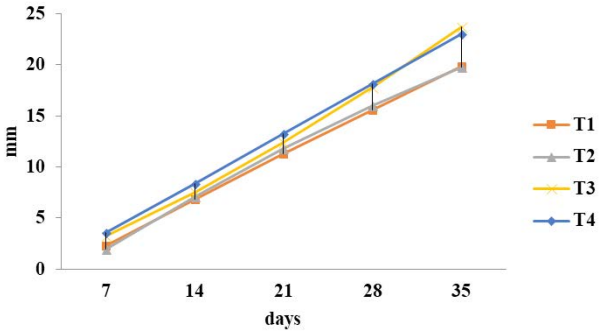

Figure 3. Effect of the application of different doses of sludge on the thickness of stem during the initial growth of the cultivation of *Z. mays*.

In relation to the average length of leaves, it was noted that the highest values were for the plants treatment T3 and T4 with a value of 43.04 and 37.26 cm respectively, which did not differ significantly from the plants T2, which showed a long average of 28.42 cm, differentiating these plants that did not receive metering with sewage sludge that reached 30.25 cm long, this indicates significant difference of 70% in relation to the application of sewage sludge in the maize crop (Figure 4).

With regard to the average width of leaves as well as in the previous variable can be seen, had the highest values

for the average width of the sheets get the treatment T4 and T3 with a value of 7.85 cm and 7.26 cm respectively, no differences were found between the two treatments. However, this if it differed from the sheet width values obtained by plants T2 and T1, which reached levels of 5.8 cm and 5.4 cm, as can be seen there is a difference a gain of 74% of the corn plants that received sludge dosing with plants witnesses or controls. So it has been pointed out that the width of the leaves of corn plants usually measured from 4 - 10.31 cm in tropical areas (Figure 5)[11].

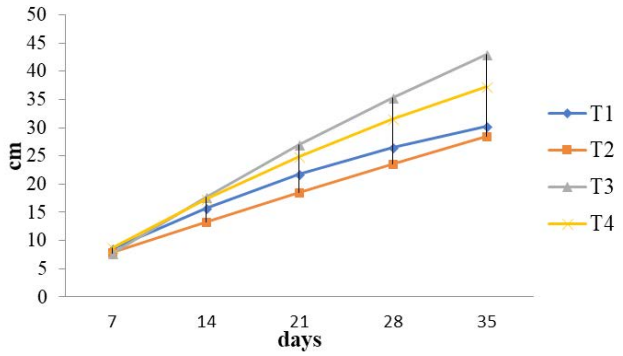

Figure 4. Effect of the application of different doses of sludge on the average length of sheet during the initial growth of Z. mays.

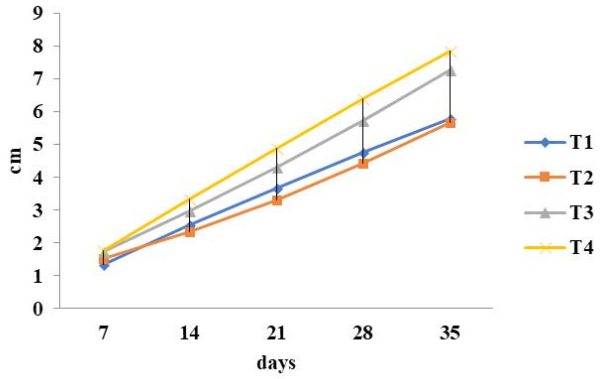

Figure 5. Effect of the application of different doses of sludge on the average width of sheet during the initial growth of Z. mays.

In the tests of mean differences were found in the plant's response to the treatments T3 and T4, with regard to the treatments T2 and T1, it appears that the differential response of maize cultivation is due to the fact that with the treatments T1 (without mud application - organic matter) and T2 (application of 52 ton.ha^{-1} of sludge - organic matter) does not cover crop nutrient demand, as can be seen in the table above). In this connection I have noted that this significant contribution in the quantities of nourishment, which could contribute to reducing the consumption of chemical fertilizers in the cultivation of Z. mays[12].

The results show that the application of sewage sludge from shrimp farm, at the time of sowing, significantly affects the emergence of maize seedlings, which could mean an alternative as the corn plants took advantage of the nutrients available in the same[9]. In this regard have been identified negative effects on crop emergence with the use of sewage sludge attributed to the levels of conductivity, indicating that levels above 3.9 dSm-1 leads to 50% reductions around in the yields of several crops. In the case of maize refuel levels of sensitivity to 1.7 dSm-1[13]. So the contribution of sludge in different doses produced greater seedling emergence and better initial development of the crop, which can be attributed to the beneficial effect of organic nitrogen nutrients 1606.8 kg/ha and 146.16 kg/ha of phosphorus in the Mix T4 in comparison with the levels present in the treatments T1 and T3 535.6 to 1071.2 kg/ha for nitrogen and from 48.72 to 97.94 kg/ha for the element phosphorus respectively[14].

Figure 6. Effect of the application of sewage sludge of the shrimp farm on the initial growth of the maize crop. a. 0% mud - organic matter, b. 2% mud - organic matter, c. 4% organic matter and mud - d. 6% mud - Organic matter.

The results of this research show high incidence that has had the treatment of mixtures with different doses of sludge in the cultivation of maize to the 35 days of the initial growth phase of the crop at all the variables evaluated. This is significant because the corn plant is very sensitive to the action of fertilizers, which allows increases in their production[8]. Achieving 83% differences obtained for the

height of plants and 76% for the thickness of the stem with a dose of 156 ton/ha. These results indicated 18% increments and 20% in the height and stem diameter of the maize crop increased but at a dose of sludge 20t·ha-1, compared to the control without application of sewage sludge, which led to improvements in maize production and the initial growth (Figure 6)[9].

According to the ANADEVA interaction between treatment and evaluation was significant (P<0.05) for the variable Leaf Area (AF), Root Dry Mass (RDM), Dry Mass of Area (DMA), according to the Tukey test (P<0.05). The highest values of AF were presented in the plants for the treatment T3 (2192.75 cm2/plant) and T4 (2082.56 cm^2/plant), significant differences between these results and the leaf area obtained in plants of the treatments with T2 (979.16 cm2/plant) and T1 which reached values for this variable (947.06 cm^2/plant), which shows a difference of 43% profit of AF.

The analysis of the results for RDM shows response similar to the previous results with significant effect (P < 0.05) of the study factors level of initial growth of maize. The results of the test of average values for the variable RDM obtained in plants for the treatment T4 with 156-ton ha-1, with values of 42.83 g, differing from the weights reached by plants d eT3 and T2 with values of 25.28 to 23.14 gr, appreciating differences with the plants witnesses whom arrived at 21.07 g, indicating a marked difference of 22 g, noting a 49 per cent gain with the application of sludge.

The MSA results shows response similar to the previous results with significant effect (P < 0.05) of the study factors level of initial growth of maize the greater weight was obtained in the plants for the treatment T4, with values of 34.34 g, followed by the plants of the T3 treatment with weights of 29, 65 g, differing from the weights reached by plants T2 and T1 with values of 13.42 to 13.46 gr, appreciating differences with the plants witnesses whom arrived at 21.07 g, indicating a marked difference of 13 g, noting a 61 per cent gain with the application of sludge.

They noted that regardless of the dose sewage sludge and compost applied as fertilizer to maize, the yields obtained were not significantly different, appreciating that both materials showed a tendency to obtain higher yields of maize[9]. Similarly, there is evidence that the increases in production when they incorporate sewage sludge are not exclusively the result of a greater contribution of nutrients to the cultivation, but also are the product of the improvements in the physical and chemical properties of the soil recipient of these organic materials[14].

4. Conclusions

Depending on the results one can indicate that the use of the sludge of the shrimp farms agriculture favors the initial growth of maize cultivation established under controlled conditions. It can be observed that the plants that showed higher levels for the evaluated variables correspond to those of the treatments T3 and T4 were not statistical differences between both treatments, indicating that regardless of the increase of 104 ton ha-1 of the mixture mud - organic matter to 156 ton ha-1, the response of the crop was similar. It is inferred that the best response from the initial growth of maize in the plants that received increased mixing mud - organic matter (T3 and T4) was due to the contribution of a highest amount of macro and micro nutrients, such as N, P, K, Ca and Mg, a sufficient amount to meet the needs of the crop during the growth phase evaluated similarly has indicated values for the width of the leaves of corn plants between 4-10 cm.

5. References

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