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ORIGINAL RESEARCH ARTICLE

Production of organic fertilizer using *pleurotus* sp. as a process accelerator

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ABSTRACT

BACKGROUND AND OBJECTIVES: One of the best retributions that man can make to the environment and that promotes development is the incorporation of waste into truly productive processes. In this sense, the main objective of this study was to take advantage of the vegetal residues from tree pruning obtained from the maintenance of the overhead wiring of the electrical networks in the city of Barranquilla, in Colombia, to produce an organic fertilizer, which are some of the most demanded products in the world. The production of organic fertilizer was carried out by composting using the *Pleurotus* sp. fungus as an accelerator of the process.

METHODS: For compost production, three treatments were used based on a mixture of manure, pruning, banana bagasse and *Pleurotus* sp. as an accelerator process. Each treatment was layered and then arranged in beds of compost piles. The temperature and humidity were monitored throughout the process. Physicochemical parameters were measured at the end of the process in concordance with the Colombian Technical Standard 5761. To evaluate the biological efficiency of the compost, two doses were tested with each 100 gram and 200 gram of fertilizer for each 500 gram of soil using corn seeds, which were sown in bags over a period of three months. At the end of the test, biological growth parameters such as foliar development, amount of biomass and fruiting were measured.

FINDINGS: Most of the physicochemical and biological parameters were within the NTC 5167 standard. The treatment with the highest percentage of degradation by composting was treatment number 2 (with *Pleurotus* sp.), which showed that with 60 percent of fresh prunings in the formulation, *Pleurotus* accelerates the process by 24 percent compared to the other treatments.

CONCLUSION: In summary, the tested method is a good route to produce fertilizers from pruning wastes. Regarding the effect of the fertilizer on the development of corn seedlings, a positive effect was observed compared to the control. Otherwise, in the composting process, the fungus significantly accelerates the process and at the same time shows an overgrowth.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
30	8	5

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INTRODUCTION

Solid waste continues to be a problem worldwide and, due to the increasing amount of organics in landfills, the generation of greenhouse gases still results from a linear economy. Many studies demonstrate models in which the production of compost from different types of waste are interesting proposals for environmental sustainability, including technological adaptations and new wastes. (Rashid and Shahzad, 2021; Ajmal *et al.,* 2021; Sun *et al.,* 2021; Cardoso *et al.,* 2022). In the main cities of Colombia, the circular economy has not yet been implemented. In the electricity sector the electrical networks are supported by poles, so foliage from trees often interferes with the power cables, causing failures in the electrical service and great economic losses. For this reason, the company that provides energy in a part of the Caribbean region, carries out periodic pruning, generating around 100 tons per month of plant biomass. Normally, the leaves are later collected by the local garbage collection company and taken to sanitary landfills (Aristizabal *et al*., 2015) where they decompose together with a large amount of solid waste, generating a negative environmental impact. A good strategy to take advantage of pruning waste and avoid the negative impact of its decomposition in sanitary landfills is the composting technique (Cestonaro *et al.,* 2021; Mishra and Yadav, 2022). Composting is a controlled degradation process, which allows aerobic bacteria and other microorganisms to decompose organic matter (e. g. leaves, grasses, wood) and generate a stable product suitable for soil treatment (Guerrero and Monsalve, 2007; Wang *et al*., 2014). Specifically, composting is the result of microbial activity that converts organic matter to more stable humic forms and other inorganic products (e.g., carbon dioxide, water, ammonia, nitrates, methane) under controlled conditions, releasing heat as a metabolic waste product (Smith *et al.,*2017). To obtain a compost that can be used in agriculture, the humid organic solids must be oxidized to more biologically stable forms such as humus and comply with regulations (NTC 5167, 2011). Different researchers have studied the acceleration of the composting process through the use of microorganisms and their enzymatic machinery. The use of cellulite microorganisms has been studied due to their ability to decompose the cellulose of the plant material into smaller units that are easy to degrade, which implies a more efficient and accelerated transformation of the composting material (Cepeda and Valencia, 2007). The use of lignolytic microorganisms is of great importance, since they do not completely mineralize the cellulose, but leave it in an intermediate state of decomposition and then repolymerize these compounds forming humic substances, reaching a material where the organic matter has not been lost, but it is stabilized in the form of recalcitrant molecules, which is what is important in a soil conditioner (Gonzalez *et al*., 2021). In this project, the production of a compost with pruning residues is proposed using *Pleurotus spp* as an accelerator of the process. Fungi of the genus *Pleurotus* are basidiomycete fungi of the order Agaricales (Aguilar *et al*., 2019), which are characterized by being efficient degraders of lignin present in plant tissues due to their ability to produce exoenzymes (Nadhim *et al*., 2017) such as laccase (Illuri *et al*., 2021; Akpinar and Urek, 2014). For this reason, and given the great lignolytic capacity of this fungus, the objective of this study focused on using the *Pleurotus* fungus as an accelerator of the composting process of pruning remains in the city of Barranquilla, as an alternative solution to the problem that involves the decomposition of these wastes in the open in the city's sanitary landfills. This study was carried out in municipaly of Malambo, Atlántico, Colombia during 2020-2021.

MATERIALS AND METHODS

Location

The experiment to produce compost was developed in the facilities of the Energy Provider Company, located in the municipality of Malambo, department of Atlántico, Colombia (latitude: 10 ° 52' North and longitude 74 ° 47' West).

Composting process

Reception of raw materials. The raw materials considered for the assembly of compost piles were bovine manure from the surrounding farms with a time not exceeding 5 days, pruning from the maintenance of the electrical networks of the city of Barranquilla and banana bagasse from the GRANABASTOS supply center. Numerous reports have presented the physical and chemical properties of bovine manure, which are important for composting. The moisture content goes from 13 to 75% weight (wt) (Font-Palma, 2019).

Elemental analysis (percent dry and ash-free basis) reported for cattle manure is 28 for carbon (C), 5.2 for (nitrogen (N) and the Carbon-nitrogen ratio (C/N) is 5. 3. (Corro, *et al*., 2013).

Pleurotus inoculum preparation

The pruning was crushed and adjusted to a granulometry of 3 – 10 centimeter (cm) and packed in polyethylene bags of 2 kilogram (kg) closed with Polyvinyl chloride (PVC) tube plastic collars and pieces of bag. The substrate was steamed at 80°C for 2 hours (h). The inoculation was carried out by supplying in each bag with substrate 90g of *Pleurotus sp* seed acquired in campingfung under sterile conditions. Incubation took place in a closed room with an average temperature of 28°C and a relative humidity of 83.3% without lighting for a month.

Assembly of composting piles

Composting piles of 1 meter (m) high and 1 m wide were assembled with a content of 150 kg of material to be composted following the layered assembly methodology, distributed in three treatments (T) and a control according to an experimental design of random blocks with two repetitions for a total of 8 experimental units. The treatments were formulated as follows:

Treatments 1 (T1)

60% vegetable residue (51.7% new pruning - 15 days cutting + 8.3% banana bagasse) and 40% manure.

Treatments 2 (T2)

60% vegetable residue (50.39% new pruning - 15 days of cutting + 9.61% banana bagasse) and 40% manure. To this treatment was added or 5.8% of the total weight of the inoculum stack of *Pleurotus* in the mycelial state.

Treatments 3 (T3)

60% vegetable residue (50.39% old pruning - 1 month cutting + 9.61% banana bagasse) and 40% manure.

Control

60% manure and 40% vegetable residue (33.3% new pruning - 15 days of cutting + 6.7% banana bagasse) (Formulation proposed by the National Education Service - SENA).

Throughout the process, the temperature and humidity of each composting pile was monitored for a period of five months. Once all the phases of the process were reached, a screening was carried out to establish the relationship between non-degraded residues vs the final product obtained using a sieve. Particles that did not pass through the sieve (equivalent to the non-degraded residue) and those that passed through the sieve (equivalent to the product obtained).

Evaluation of quality parameters

A sample was taken from each compost pile. The samples were analyzed in the laboratory of the University of Antioquia. The analyses carried out were: physicochemical analysis, heavy metal content, microbiological analysis, phytotoxicity and respirometry, according by the Colombian Technical Standard (NTC 5167, 2011) for compost.

Biological efficiency test of the compost obtained

To measure the effect of compost on plant growth, a biological efficiency test was performed. For the biological test, doses (in triplicate) of 100 gram (g) and 200 g of compost obtained from the eight composting piles were applied to corn seeds, sown in bags of 500 g capacity, for a period of 3 months, following a completely randomized experimental design and one control (without fertilizer). The soil used was the one used for construction, which is characterized by a low content of organic matter. At the end of the test, growth parameters were measured. At the foliar level, the area and total biomass were measured; at the fruit level, the number of cobs, length, weight, number and weight of the grains were measured. For the total leaf area, the length of each of the leaves per plant leaf x maximum leaf width x 0.75 was measured (García *et al.,* 2020). For the determination of the total biomass, the leaves were cut, packed in kraft paper and dried in an oven at 70 °C to a constant weight.

Data analysis

The data obtained were subjected to an analysis of variance to determine significant differences in the mean percentage of degradation through the composting process between treatments. The null hypothesis (Ho) was contrasted that all treatments formulated for the composting process had the same average percentage of degradation of plant waste vs the alternative hypothesis (H1) that at least a couple of formulations had a different average degradation percentage at a significance level of 5%. For the separation of treatments with similar effects was applied to the multiple-range test of fisher's least significant difference (LSD). The analyses were carried out with the Statgraphics Centurion software.

RESULTS AND DISCUSSION

Raw materials

The analysis of the microbiological quality of the raw materials showed the presence of the phytopathogenic fungus of the genus *Phoma* in the pruning as well as the presence of nematodes in the used manure (Table 1). Despite this, raw materials of plant origin should only be free of phytopathogens of the genera: *fusarium sp; botrytis sp; rhizoctonia sp; phytophthora sp*. as well as phytopathogenic nematodes (NTC 5167, 2011). It is emphasized that it refers to a total count, not a count of phytopathogenic nematodes. Several authors emphasize that nematodes are one of the most abundant organisms in the soil, these microorganisms can be found as parasites in plants and animals; also, free-living nematodes (saprophytes) were found (Franco and Muñoz, 2004). This second group can be used as an indicator of the quality of soils due to the great diversity of species that exist (Sanchez and Talavera, 2013). Neither of these two types of microorganisms was evidenced in the final product for any of the treatments, which supports that the process reached the thermophilic phases (temperatures above 45°C) where pathogenic microorganisms are eliminated.

Obtaining the compost

The null hypothesis (Ho) was contrasted that all treatments formulated for the composting process had the same average percentage of degradation of plant waste vs the alternative hypothesis (H1) that at least a couple of formulations had a different average degradation percentage. The analysis of variance showed that Ho is rejected *(F(3,4)=17.55, p-value=0.01)*. The multi-range test showed that T2, in which *Pleurotus* inoculum was used as a differentiating factor, had an average degradation percentage of 41.7% (*SD*=1.7) which is statistically higher than that obtained by the control, *(M=25.7, SD=0.9)* and treatment 1, *(M=17.9, SD=3)*. It is found that by using *Pleurotus* in the composting process of vegetable waste of 15 days of cutting increases production by up to 24% approximately (Fig. 1). A similar result was obtained in the bioconversion of lignolytic residues using *Pleurotus sp*, with percentages close to 50%; stating that value exceeds the range of biotransformation in different waste treatments with *Pleurotus*, which ranges from 16.7% to 38.8% (Arias *et al.,* 2005). According to the results obtained, when using *Pleurotus sp.* in the composting process, it manages to accelerate production in a period of 5 months, which is positive considering that composting is completed in approximately one year without this fungus (Arrigo *et al.,* 2005). The acceleration of the process was due to the ability of the fungi of this genus to produce exoenzymes of high catalytic oxidoreductases such as peroxidases and oxidases, as well as intracellular enzymes such as hydroxylases, decarboxylases, dioxygenases, reductases and transferases (Del Cerro *et al*., 2021). On the other hand, many researchers (Jusoh *et al*., 2013; Sharma

Table 1: Quality parameters for raw materials

Organoleptic test				
Raw material	State	Color	Texture	
Prunning	Wet solid	Brown	Thick and heterogeneous	
Manure	Wet solid	Brown	Thick and heterogeneous	
Banana bagasse	Wet solid	Brown	Thick and heterogeneous	
Microbiological analysis				
Raw material	Mold UFC/g*	Yeast UFC/g	Nematodes and protozoa	Phytopathogen
Prunning	1,7 ± 0,4	0 ± 0,0	Not found	Phoma sp.
Manure	2,0 ± 0,1	0 ± 0,0	Found	-
Banana bagasse	2,2 ± 0,2	0 ± 0,0	Not found	-

*Colony forming units per gram

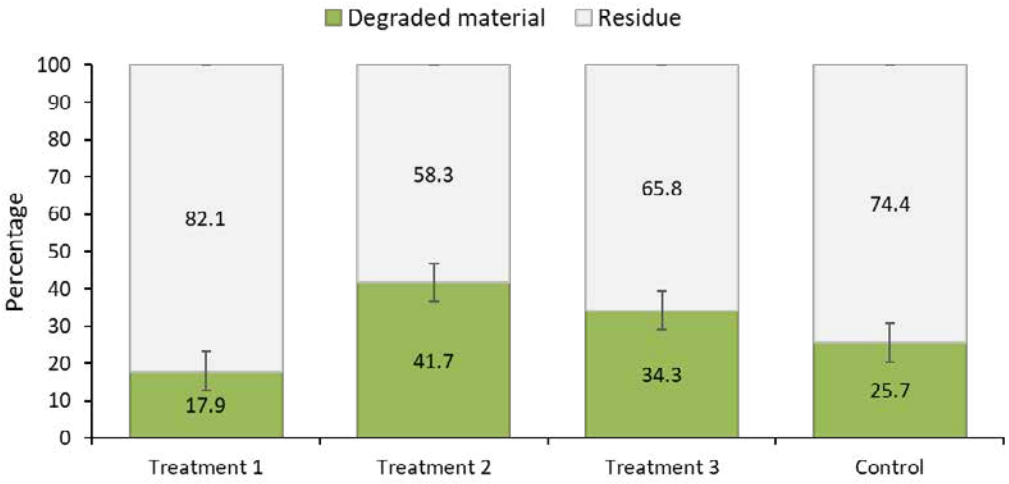

Fig. 1: Percentage of degraded material vs Residue per treatment

et al., 2014; Karnchanawong and Nissaikla, 2014; Zhao *et al.*, 2017) have used efficient microorganisms to accelerate the process (Rastogui *et al.,* 2020), but there are few studies focused on evaluating the quality of the product obtained according to the parameters established by the standard (NTC 5167, 2011).

The initial temperature in all the piles of the different treatments was close to room temperature, then it increased over time, which indicates that the reactive organic transformation process is exothermic. The maximum temperature reached in T1 was 53 °C, in T2 it was 60 °C, in T3 it was 58 °C and the control (treatment 4) was 44 °C, the latter being the one in which the temperature increased the least, since it was kept between 44 and 32 °C throughout the process. The temperatures were like those reached in other composting studies (Chaves *et al.*, 2019) other studies without fungal treatments and when depleted substrates with *Pleurotus* mushrooms are used in compost production (Hernández *et al.*, 2021; Gonzalez *et al.,* 2015). Aerobic composting is characterized by the predominance of aerobic respiratory metolisms and by the alternation of mesophilic stages (10-40 °C) with thermophilic stages (40-75 °C), and with the participation of mesophilic and thermophilic microorganisms (Delgado *et al.,* 2019; Ajmal *et al.,* 2021). A low temperature in the pile is due to the fact that the size is very small, the wrong C/N ratio, lack of humidity and/or too much oxygen, based on these considerations T2 was the one that was best oriented towards the formation of compost (Cardona and Hernández, 2008).

Physicochemical parameters

Most of the physicochemical parameters used to evaluate the physicochemical quality of the compost obtained in the different treatments were within the reference values established by NTC 5167, with the exception of the Cationic interchange (CIC) and ash parameters, which were slightly above the norm by 30 meq/100g approximately. This property is highlighted because is very important in the absorption of minerals, which is why it has a positive effect on plant growth (Table 2); (Sánchez *et al.,* 2019). Another parameter that was slightly above the norm was pH, registering values from 9.04 to 9.38 (acceptable pH of the NTC 5167 is 4-9), which suggests that the process had not yet fully matured, since during the composting process, this parameter behaves as follows: initially the pH drops, as a consequence of the fundamentally bacterial metabolism that transforms easily decomposable carbon complexes in organic acids; then, the pH increases as a consequence of the formation of ammonia, reaching the highest value, around 8.5, coinciding with the maximum activity of the thermophilic phase. Then, the pH decreases in the final or maturation phase (pH between 7 and 8) due to the natural properties of the organic matter buffer or buffer (Delgado Arroyo *et al.,* 2019). The great importance of this measure lies in the fact that this parameter can affect crop production when applied to the soil, since it alters the pH of the soil and influences the absorption of heavy metals (Guerrero and Monsalve, 2007). Minimal concentrations of heavy metals were found (about 2-6 ppm), more specifically cadmiun, nickel, and lead; all concentrations were under the established by NTC 5167. Although vegetable residues do not contain heavy metals, it is presumed that the heavy metals found come from exposure to automotive emissions and industrial gases from the city. As stated above, the vegetable waste comes from the city, which is exposed to all emissions. Other bioelements that contribute to plant growth, such as nitrogen, phosphorous, magnesium, zinc, potassium were also found in concentrations above 1% (Table 2). The humidity was also above the controlled parameters. None of the compost obtained showed the ideal humidity for the product (max. 35% for products of plant origin), which is due to the very nature of the pruning, which contains approximately 70%. Avoiding excess moisture is especially important for the destruction of pathogens during composting (Roy *et al*., 2021). Despite the moisture values obtained, in this research, the presence of pathogenic microorganisms was not evidenced. The carbon/nitrogen ratio (C/N) was below the ideal (15-18), showing values around 11-12; this parameter determines the maturity of the compost (Albarracín *et al.,* 2018). According to this result and the pH, it can be stated that the proposed treatment should increase the maturation time; on the other hand, this relationship was low due to the low percentage of oxidizable carbon in the product, which was <15%. With respect to particle size, 68% of the particles were smaller than 2 mm, which improves the performance of the reaction, since it increases the contact area between the reactive sites.

Statistical analysis of the physicochemical and biological parameters

To establish similarities between the treatments, a multifactorial analysis of variance (ANOVA) was performed at 95% confidence. Statistical significance values (p) above 0.05 indicate that the treatments showed the same physicochemical and biological properties; in contrast, p values below 0.05 indicate that the treatments are different. The ANOVA analysis showed significant differences when comparing the treatments T1-T3, T1-control, T2-T3, and T1-control,

Table 2: Physicochemical parameters of the treatments

Parameter	NTC 5167	T1	T2	T3	Control
Aluminiun (Al) total (%)		ND	ND	ND	ND
*Cadmiun (Cd) total (pmm)	39	2,00 ± 0,08	0,80 ± 1	1,7 ± 0,3	1,75 ± 0,07
Calcium (Ca) total (%)		2,94 ± 0,06	14 ± 8	3,8 ± 0,5	3,3 ± 0,9
*Cromium (Cr) total (pmm)		0,02 ± 0	13 ± 13	9 ± 7	17 ± 11
Magnesium (Mg) total (%)		ND	0,96 ± 0,05	1,1 ± 0,4	0,6 ± 0,8
*Nickel (Ni) total (pmm)	420	6 ± 2	29 ± 7	30 ± 9	34 ± 15
**Lead (Pb) (%)	300	3 ± 1	2 ± 2	3 ± 1	4 ± 3
Potasium (K) total (%)		2,43 ± 0,01	2.3 ± 0.3	2,5 ± 0,2	2,5 ± 0,1
Sodium (Na) total (%)		2,5 ± 0,1	ND	ND	1 ± 2
Zinc (Zn) total (%)		ND	ND	ND	ND
**Ash (%)	60	68 ± 1	70 ± 2	69 ± 11	61 ± 9
*CIC (meq/100g)	30	61 ± 2	56,6 ± 0,6	58 ± 16	57 ± 9
CIC/CO (meq/100g)		510 ± 17	478 ± 79	424 ± 28	410 ± 146
** oxidable organic Carbon (%)	15	12 ± 0,9	12 ± 2	14 ± 3	14 ± 3
Eletrical Conductivity		0,30 ± 0,01	0,18 ± 0,04	0,2 ± 0,1	0,3 ± 0,1
CRA (%)		108,6 ± 0,9	118 ± 17	112 ± 40	138 ± 32
*Density (g/cm^3)	0,60	0,8 ± 0,1	0,7 ± 0,1	0,9 ± 0,1	**0,7 ± 0,3
Total Phosphorus (P) (%)		1,00 ± 0,03	0,54 ± 0,04	0,7 ± 0,3	0,62 ± 0,01
**Humidty (%)	35	54 ± 1	50 ± 2	51 ± 11	56 ± 5
*Total organic Nitrogen (N) orgánico (%)		1,43 ± 0,2	1,14 ± 0,07	1,2 ± 0,5	1,4 ± 0,3
**pH (10%)	4 - 9	9,27 ± 0,01	9,1 ± 0,2	9,0 ± 0,2	9,31 ± 0,02
C/N ratio		8,6 ± 0,3	11 ± 3	12 ± 2	11 ± 5
Particle size >2 mm (%)		38 ± 6	14 ± 9	30 ± 14	28 ± 14
Particle size <2 mm (%)		62 ± 6	86 ± 9	70 ± 14	72 ± 14

*Parameters required by NTC 5167.

** Parameters required by NTC 5167 values above or below the reference value.

while the treatments T2-control and T1-T2 were similar according to physicochemical properties. For its part, the ANOVA analysis for the biological parameters showed that all the p values are above 0.05, not refusing the null hypothesis that the treatments had equals biologicals properties (Table 3).

Microbiological quality of compost

The compost obtained in the different treatments complies with the parameters determined by NTC 5167. Table 4 shows that the parameters nematodes and protozoa, Enterobacteriaceae, and Salmonella are absent or within the level accepted by said rule. Regarding the other parameters, the analysis found mesophiles and thermophiles in approximately 8E08 (UFC/100g), molds were found at a magnitude of 3, and in the final product were not found yeasts.

Phytotoxicity and respirometry of compost

The phytotoxicity of the compost was evaluated in radish seed, showing a decrease in the percentages of germination of the compost obtained in all treatments and the control, which means that it generates a toxic effect in this plant type (Table 5). The phytotoxicity

Table 3: Probability value at a statistical significance level of 95%

Combination	p-value (physicochemical parameters)	p-value (Biological parameters)
T1—T2	0,9154	0,7857
T1—T3	0,0002	0,0672
T1—CONTROL	0,0036	0,2486
T2—T3	0,0071	0,4594
T2—CONTROL	0,8131	0,9281
T3—CONTROL	0,0000	0,2719

Table 4: Microbiological parameters by treatments

Parameter	NTC 5167	T1			T2			T3			Control		
**Mesophiles (UFC/100g)	----	1,8 E+08	±	0,1	4 E+08	±	1	6,4 E+08	±	0,1	2,8 E+08	±	0,4
Thermophiles (UFC/100g)	----	2,7 E+08	±	0,9	5 E+08	±	3	2 E+09	±	2	1,7 E+09	±	0,9
**Molds (UFC/100g)	----	4,0 E+03	±	0,6	2 E+03	±	2	2 E+04	±	3	1 E+04	±	1
**Yeast (UFC/100g)	----	0,00	±	0,00	0,00	±	0,00	0,00	±	0,00	0,00	±	0,00
Nematodes and/or Protozoa (Found/Not found)	Not found	Not found			Not found			Not found			Not found		
*Enterobacteria (UFC/100g)	1000	2 E+02	±	3	1,5 E+02	±	2	6 E+02	±	1	1 E+02	±	1
*Salmonella (Found/Not found)	Not found	Not found			Not found			Not found			Not found		

*Parameters required by NTC 5167.

** Parameters required by NTC 5167 values above or below the reference.

Table 5: Phytotoxicity and respirometry tests to treatments

Parameter	Unit	Treatment 1			Treatment 2			Treatment 3			Control		
Phytotoxic at 2.5	% Germinación	40	±	7	50	±	0	60	±	14	35	±	0
Phytotoxic at 5.0	% Germinación	50	±	7	53	±	11	48	±	11	38	±	18
Phytotoxic at 7.5	% Germinación	48	±	18	33	±	18	43	±	4	35	±	21
Phytotoxic at 10.0	% Germinación	38	±	18	48	±	18	65	±	7	15	±	14
Parameter	Unit	Treatment 1			Treatment 2			Treatment 3			Control		
Respirometry 24 hrs	mg CO_2/g	0,28	±	0,03	0,22	±	0,06	0,2	±	0,1	0,26	±	0,00

is due to heavy metals presence or high salt content (Peña *et al.,* 2020), but the electrical conductivity values in this research were low. Regarding respirometry, the compost obtained in the different treatments presented values lower than 2 mg CO_2/g total volatile solids (SVT), which means that the material is stable, does not continue decomposition, and does not produce odor (Soto and Meléndez, 2004).

Biological efficiency of fertilizers

The biological efficiency test of the fertilizers was carried out on corn seedlings. To evaluate the efficiency and effect of the compost several factors were measured, among them the foliar development (area and biomass) of the corn seedlings. The descriptive analysis showed a positive effect in some treatments and doses for the different parameters evaluated compared to the control. Specifically, with doses of 100 g of compost from treatment 2, cobs with greater length were obtained, but for the rest of the parameters monitored with 100 g of compost obtained from treatment 3 achieved higher averages. In summary, the fertilizers of treatments 2 and 3 at a dose of 100 g per 500 g of soil were the ones that had the better biological results. Specifically, when treatment 3 was compared with the control, a notable difference was found, suggesting the proposed composting as a viable route for soil preparation for corn planting. Treatment number one in a dose of 100 g showed a lower effect than the control treatment, which indicates that this treatment supplied a lower amount of nutrients to seedlings, necessary for the development of the leaf area. This difference is due to the release of nutrients by the compost and the

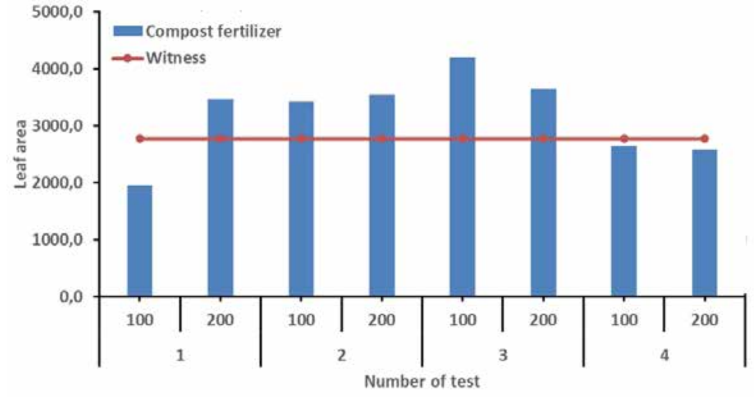

Fig. 2: Average total leaf area per treatments, a = 100g dose, b = 200g dose

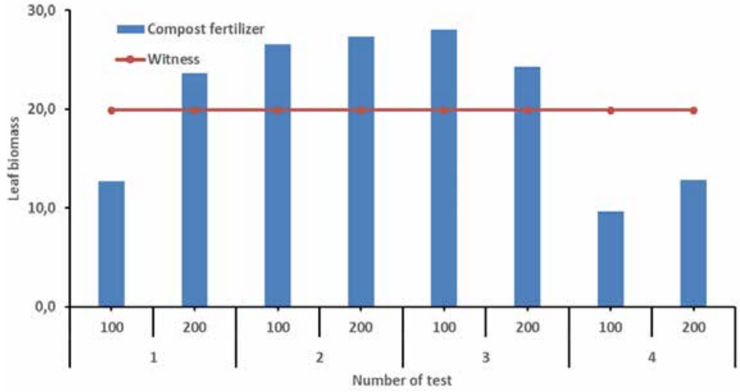

Fig. 3: Averages of total foliar biomass by treatments, a = dose of 100 g, b = dose of 200 g

subsequent absorption by the plants and due to the vital role of the compost application in improving soil properties (Asadu *et al.,* 2018; Zheng *et al.,* 2022). In a study conducted by Kadil *et al.* (2020) related to Potentials of organic manure and potassium forms on maize (Zea mays L.) growths and production was observed a strong positive correlation between soil amendment (compost), and plant height, ear length, grains number/row, grains number/row, 100- grain weight (Figs. 2 to 7).

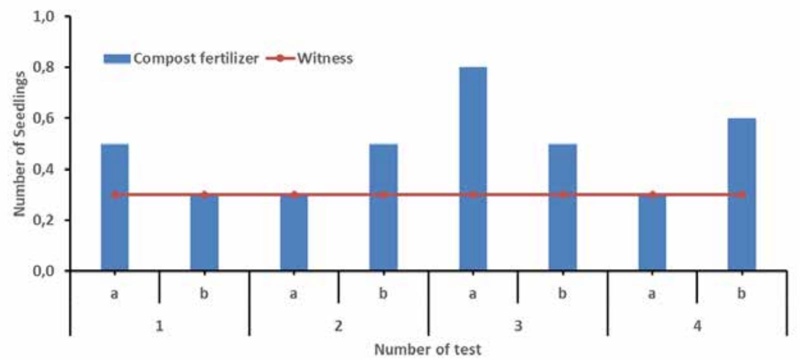

Fig. 4: Averages of the number of ears harvested by plants in each treatment, a = dose of 100 g, b = dose of 200 g

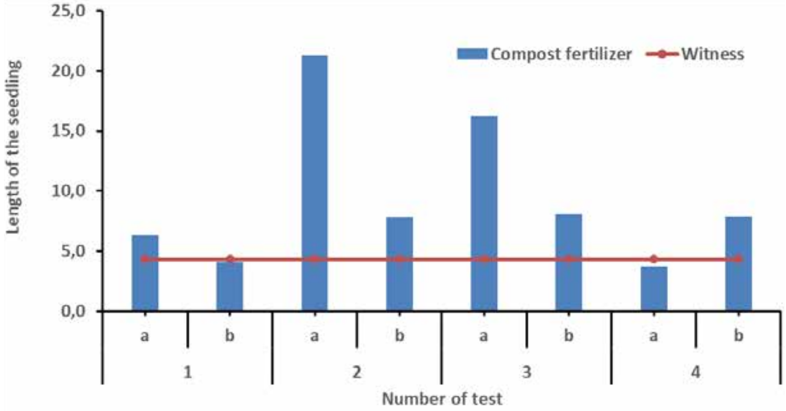

Fig. 5: Averages the length (cm) of the ears harvested in each treatment, a = dose of 100 g, b = dose of 200 g

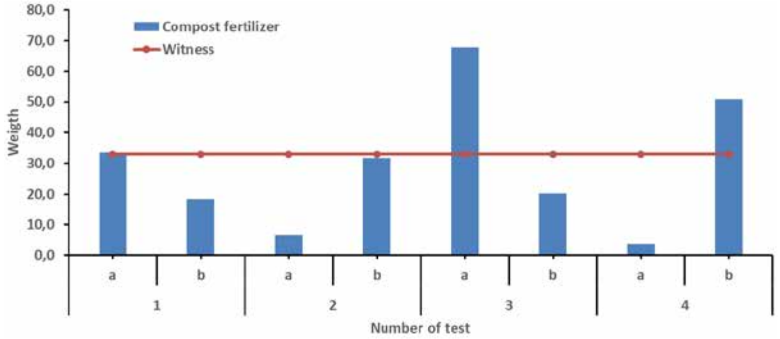

Fig. 6: Average weight (g) of the ears harvested in each treatment, a = dose of 100 g, b = dose of 200 g

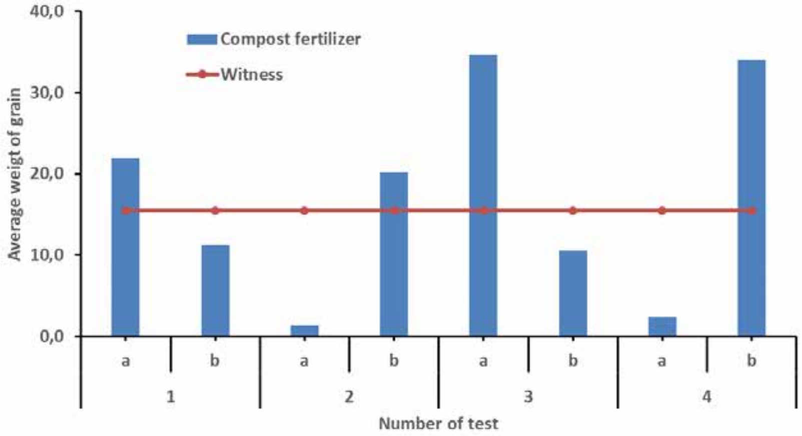

Fig. 7: Average weight of grain (g) of the ears harvested in each treatment, a = dose of 100 g, b = dose of 200 g

Fig. 8: Mycelial growth and fruiting bodies of *Pleurotus sp*. on pruning

Growth of Pleurotus sp

As an additional result of this project, due to the experimental area reaching temperatures of up to 33°C and *Pleurotus* growing at 25°C (Barba *et al*., 2019), a good growth of the fungus was obtained under the environmental conditions of the region, evidenced in the greats development of the fruiting bodies of *Pleurotus sp*. It showed that the pruning material could be a suitable substrate for the growth of this fungus of commercial interest due to its nutritional qualities (Fig. 8).

CONCLUSION

This study provides a solution not only for Colombia but for any other country that is experiencing strong pressure on its landfills that are reaching their storage capacity and must generate urgent solutions for the management and use of organic waste. The volume of solid waste is one of the main problems, which in most cases ends up in landfills. In particular, large pruning residues would cease to be unusable waste and would be put to industrial use. Concerning the experiment, the fungus markedly accelerated the composting process and the compost yield obtained from pruning. Also, the fertilizer obtained notably stimulated the growth of the seedlings tested such as corn, this result was evidenced in terms of length of seedlings, weight of seedlings, leaf area, leaf biomass and other parameters. According to what was observed in the biological efficiency test for corn crops, it can be suggested that the proposed formulation, both

Treatment 2 and Treatment 3, can be used at an industrialized level with some adjustments. Another appreciated result was the abrupt growth of the fungus used as a process accelerator, which can be used for medicinal and food purposes. Considering the parameters regulated by the Colombian National Standard, most of the physicochemical and microbiological parameters monitored were within the value accepted by NTC 5167. Some the results showed a slight increase in pH and moisture, suggesting an increase in composting time. Sometimes it was necessary to adjust them to obtain statistically significant results in relation to the effect of the different treatments and the doses of compost applied. With respect to heavy metal toxicity, all of them are below the NTC 5167 standard, which is a very important result since the waste comes from an industrialized area and a high value could be expected. Biological parameters such as Mesophiles, Thermophiles, Molds, Yeast, Nematodes were under the allowable limit value established by standard. The process successfully eliminated the nematodes present in the manure used in the treatments. In summary, the solid organic residues from pruning and the formulations used in this research constitute an important raw material to produce fertilizer from composting, which could be used to stimulate the growth of agricultural plants. Further, the world economy is going through a conjunctural moment, states are promoting the development of applications within the framework of the circular economy, mainly aimed at the reuse of waste for the production of new materials. This method opens an opportunity for the development of usable materials in agriculture.

AUTHOR CONTRIBUTIONS

A. Medina-Buelvas performed the experimental design, sampling campaigns, compost quality analysis, interpreted the data and results, and prepared the manuscript text. A. García-Cuan made the fungal inocula and interpreted the data and results. B. Barraza- Amador Performed the biological efficiency assay, prepared the manuscript text and manuscript edition. E. Espinosa-Fuentes analyzed, interpreted the data and results, and prepared the manuscript edition. K. Mendez performed the experimental design, analyzed, and interpreted the data and results. M. Del Castillo monitored the process and prepared the manuscript text. N. Rosales managed supplies, adaptation, and control of pilot plants.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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PUBLISHER'S NOTE

ABBREVIATIONS

°C	Degree centigrade
%	Percent
Al	Aluminiun
ANOVA	Analysis of variance
Ash	Ash content determination
Ca	Calcium

Cd	Cadmium
CIC	Cationic interchange
CIC/CO	Cationic interchange on organic carbon
cm	Centimeter
C/N	Carbon-nitrogen ratio
CO	Oxidable carbon
CO_2/g	Carbon dioxide per gram
Cr	Chromiun
CRA	Capacity of water retention
Fig.	Figure
g	Gram
g/cm^3	Gram per cubic centimeter
h	Hours
K	Potassium
kg	Kilogram
LSD	Fisher’s least significant difference test
Max.	Maximum
Meq/100g	Millequivalents per 100 grams
Mg	Magnesium
mg	Milligram
mg CO_2*/g*	Milligram of carbon dioxide per gram
mm	Millimeter
N	Nitrogen
Na	Sodium
ND	Not detected
Ni	Nickel
NTC	Colombian technical standard
P	Phosphorus
Pb	Lead
pH	Hydrogen potential
Pleurotus sp.	Scientific name of fungus
pmm	Maximum allowable
p-value	Probability value
PVC	Polyvinyl chloride
SENA	National Education Service
sp	Specie
SVT	Total volatile solids
T1	Treatment 1
T2	Treatment 2
T3	Treatment 3
UFC/g	Colony forming units per gram
wt	Weight
Zn	Zinc

REFERENCES

Aguilar, F.; Human, H.; Holgado, M., (2019). Caracterización de *Pleurotus* sp. aislado de la comunidad nativa de Korimani, centro poblado kiteni-echaratie, la convención, Cusco, Perú. Ecol. Aplicada., 18(1): 46-50 (**5 pages**).

Ajmal, M.; Shi, A.; Awais, M.; Mengqi, Z.; Zihao, X.; Shabbir, A.; Faheem, M.; , Wei, W.; Ye, L., (2021). Ultra-high temperature aerobic fermentation pretreatment composting: Parameters optimization, mechanisms and compost quality assessment. J. Environ. Chem. Eng., 9(4): 105453 (**11 pages**).

Akpinar, M.; Urek, R., (2014). Extracellular ligninolytic enzymes production by Pleurotus eryngii on agroindustrial wastes. Prep. Biochem. Biotechnol., 44(8): 772-781 (**10 pages**).

Albarracín, D.; Roa, A.; Solano, F.; Montañez, G., (2018). Producción de abono orgánico mediante el compostaje aerotérmico de residuos de poda. Rev. Bistua Facultad de Ciencias Básicas., 16(1): 156-162 (**7 pages**).

Arias, G.; Bueno, M.; Betancourt, G.; Rodríguez, D.; Álvarez, I.; González, A., (2005). Biotransformación de residuos lignocelulósico con hongos Pleurotus. Revista CENIC. Ciencias Biológicos., 36: 1-8 (**8 pages**).

Aristizabal, B.; Vanegas, E.; Mariscal, J.; Camargo, M.; (2015). Digestión anaerobia de residuos de poda como alternativa para disminuir emisiones de gases de efecto invernadero en rellenos sanitarios. Energética., 46: 29-36 (**8 pages**).

Arrigo, N.; Jiménez, M.; Palma, R.; Benito, M.;Tortarolo, M., (2005). Residuos de poda compostados y sin compostar: uso potencial como enmienda orgánica en suelo. Ciencia del suelo, 23(1): 87-92 (**6 Pages**).

Asadu, Ch.; Aneke, N.; Egbuna, S.; Agulanna, A., (2018). Comparative Studies on the Impact of Bio-Fertilizer Produced From Agro-Wastes Using Thermo-Tolerant Actinomycetes on the Growth Performance of Maize (Zea-Mays) and Okro (Abelmoschus Esculentus). Environ. Technol. Innovation., 12: 55-71 (**17 pages**).

Barba, M.; Assumpção, F.; Aparecida, H.; Lopes, G.; Ávila, S.; Silveira, P.; Maccari, A.; Hoffmann, R., (2019). Factors affecting mushroom *Pleurotus* spp. Saudi J. Biol. Sci., 26: 633–646 (**14 pages**).

Cardona Castelblanco, S.; Hernández Rios, L., (2008). Aprovechamiento de residuos de poda mediante compostaje en la escuela militar de aviación Marco Fidel Suarez. Pasantía para optar al título de Administradoras Ambientales. Universidad Autónoma de Oriente. Colombia (**117 pages**).

Cardoso, P.H.S.; Gonçalves, P.W.B.; Alves, G.O.; Pegoraro, R.F.; Fernandes, L.A.; Frazão, L.A.; Sampaio, R.A., (2022). Improving the quality of organic compost of sewage sludge using grass cultivation followed by composting. J. Environ. Manage., 314: 115076 (**8 pages**).

Cepeda, L.; Valencia, S., (2007). Aislamiento de bacterias lipolíticas y determinación de patógenos humano Echerichiacoli y Salmonella sp. a partir de residuos orgánicos domiciliarios en pompostaje. Thesis de pre-grado. Pontificia Universidad Javeriana. Colombia (**105 pages**).

Cestonaro, T.; De Vasconcelos, R.; De Matos, A.; Azevedo, M., (2021). Full scale composting of food waste and tree pruning: How large is the variation on the compost nutrients over time? Sci.Total Environ., 1(754): 1-9 (**9 pages**).

Corro, G.; Paniagua, L.; Pal, U.; Bañuelos, F.; Rosas, M., (2013). Generation of biogas from coffee-pulp and cow-dung codigestion: Infrared studies of postcombustion emissions. Energy Convers. Manage.,74: 471-481 (**11 pages**).

Chaves, R.; Campos, R.; Brenes, L.; Jiménez, M., (2019). Compostaje de residuos sólidos biodegradables del restaurante institucional del Tecnológico de Costa Rica. Tecnología en Marcha., 32(1): 39-53 (**15 pages**).

Del Cerro, C.; Erickson, E.; Dong, T.; Wong, AR.; Eder, EK.; Purvine, S.; Mitchell, HD.; Weitz, KK.; Markillie, LM.; Burnet, MC.; Hoyt, DW.; Chu, RK.; Cheng, JF.; Ramirez, KJ.; Katahira, R.; Xiong, W.; Himmel, ME.; Subramanian, V.; Linger, JG.; Salvachúa, D., (2021). Intracellular pathways for lignin catabolism in white-rot fungi. Proc Natl Acad Sci., 118(9): e2017381118.

Delgado, M.; Mendoza, K.; González, M.; Tadeo, J.; Martín, J., (2019). Evaluación del proceso de compostaje de residuos avícolas empleando diferentes mezclas de sustratos. Rev. Int. Contam. Ambie., 35(4): 965-977 **(13 pages).**

Franco, O.; Muñoz, N., (2004). Medición de la sostenibilidad en la finca bananera de la Universidad Earth: Nemátodos y materia orgánica como indicadores de calidad de suelo. Tesis de licenciatura. Escuela de Agrilcultura de la Región del Trópico Húmedo. Costa Rica **(79 pages).**

Font-Palma, C., (2019). Methods for the Treatment of Cattle Manure—A Review. J. Carbon Res., *5*(2): 27 **(20 pages).**

García, E.; Díaz, P.; Hidalgo, E; Oniel, J.; Aguirre, G., (2020). Respuesta del cultivo de maíz a concentraciones de estiércol bovino digerido en clima tropical húmedo. Manglar., 17(3): 203-208 (**6 pages**).

González, A.; Alba, F.; Martínez, F.; Alfonso, J.; Castejón, M., (2015). Composting of Spent Mushroom Substrate and Winery Sludge. Compost Sci. Util., 23: 58–65 (**8 pages**).

González, A.; Sigala, S.S.; Tapia, M.; Cruz, M.B.; Rodríguez, R.M.; Loredo, A.; Contreras, J.C.A.; Belmares, R., (2021). Efecto de diferentes sustratos sobre la cinética enzimática de Pleurotus ostreatus. Revista Internacional de Investigación e Innovación Tecnológica., 9(49): 20-39 (**20 pages**).

Guerrero, J.; Monsalve, J., (2007). Evaluación del compostaje de subproductos derivados del sacrificio y faenado del ganado. Scientia et Technica Año XIII., (34): 595-600 (**6 pages**).

Hernández, D.; Ros, M.; Carmona, F.; Saez, J.; Pascual, J., (2021). Composting Spent Mushroom Substrate from Agaricus bisporus and Pleurotus ostreatus Production as a Growing Media Component for Baby Leaf Lettuce Cultivation under Pythium irregulare Biotic Stress. Horticulturae. 7(13): 2-13 (**12 pages**).

Illuri, R.; Kumar, M.; Eyini, M.; Veeramanikandan, V.; Almaary, K.S.; Elbadawi, Y.B.; Biraqdar, M.A.; Balaji, P., (2021). Production, partial purification and characterization of ligninolytic enzymes from selected basidiomycetes mushroom fungi. Saudi J. Biol. Sci., 28(12): 7207-7218 (**12 pages**).

Jusoh, M.; Manaf, L.; Latiff, P., (2013). Composting of rice straw with effective microorganisms (EM) and its influence on compost quality. Iran. J. Environ. Health Sci. Eng., 10(1): 17 (**9 Pages**).

Kandil, .; Abdelsalam, N.R.; Mansour, M. A.; Ali, H.; Siddiki, M., (2020). Potentials of organic manure and potassium forms on maize (Zea mays L.) growth and production. Sci. Rep. 10: 8752 (**11 pages**).

Karnchanawong S.; Nissaikla S., (2014).Effects of microbial inoculation on composting of household organic waste using passive aeration bin. Int. J. Recycl. Org. Waste Agric., 3(4): 113–119 (**7 Pages**).

Mishra, S.K.; Yadav, K.D., (2022). Assessment of the effect of particle size and selected physico-chemical and biological parameters on the efficiency and quality of composting of garden waste. J. Environ. Chem. Eng., 10(3): 107925 (**17 pages**).

Nadhim, M.; Ali, I.; Saleem, S., (2017). Applicable properties of the bio-fertilizer spent mushroom substrate in organic systems as a byproduct from the cultivation of Pleurotus sp. Inf. Process. Agric., 4: 78–82 (**5 pages**).

NTC 5167, (2011). Norma Técnica Colombiana para productos de la industria agrícola productos orgánicos usados como abonos o fertilizantes y enmiendas de suelo.

Peña, H.; Mendoza, H.; Dianez, F.; Santos, M., (2020). Parameter Selection for the Evaluation of Compost Quality. Agronomy. 10: 1567 (**17 pages**).

Rashid, M.; Shahzad, K., (2021). Food waste recycling for compost production and its economic and environmental assessment as circular economy indicators of solid waste management. J. Clean. Product., 317: 128467 (**11 pages**).

Rastogi, M.; Nandal, M.; Khosla, B., (2020). Microbes as vital additives for solid waste composting. Heliyon. 6(2) (**11 Pages**).

Roy, E.; Esham, M.; Jayathilake, N.; Otoo, M.; Koliba, Ch.; Wijethunga, I.; Fein, C., (2021)..Compost quality and markets are pivotal for sustainability in circular food-nutrient systems: a case of study of Sry Lanka. Front. Sustain. Food Syst., 5: 748391 (**15 pages**).

Sharma, A., Sharma, R., Arora, A., Shah, R., Singh, A., Pranaw, K., & Nain, L. (2014). Insights into rapid composting of paddy straw augmented with efficient microorganism consortium. Int. J. Recycl. Org. Waste Agric., **3:** 54 **(9 pages).**

Sun, C.; Wei, Y.; Kou, J.; Han, Z.; Shi, Q.; Liu, L.; Sun, Z., (2021). Improve spent mushroom substrate decomposition, bacterial community and mature compost quality by adding cellulase during composting. J. Clean. Product., 299: 126928 (**11 pages**).

Wang, K.; Li, X.; He, C.; Chen, C.L.; Bai, J.; Ren, N.; Wang, J.Y., (2014). Transformation of dissolved organic matters in swine, cow and chicken manures during composting. Bioresour. Technol., 168: 222–228 (**8 pages).**

Zhao, Y.; Zhao, Y.; Zhang, Z.; Wei, Y.; Wang, H.; Lu, Q., (2017). Effect of thermo-tolerant actinomycetes inoculation on cellulose degradation and the formation of humic substances during composting. Waste Manage., 68: 64–73 **(10 Pages)**.

Zheng, W.; Ma, Y.; Wang, X.; Wang, X.; Li, J.; Tian, Y.; Zhang, X., (2022). Producing high-quality cultivation substrates for cucumber production by in-situ composting of corn straw blocks amended with biochar and earthworm casts. Waste Manage., 139: 179–189. (**11 pages).**

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