Performance of grape marc and organic residues compost as substrate in lettuce (*Lactuca sativa*) seedlings

Eficiencia del compost de orujo de uva y residuos orgánicos como sustrato en plantines de lechuga (*Lactuca sativa*)

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Abstract

Composting is an aerobic process used to treat organic residues, which results in a high quality product, able to be adopted as plant substrate or soil amendment. In the present study, the performance of compost on the germination and biomass of *Lactuca sativa* var Grand rapids seedlings, with and without fertilization, was evaluated. The two types of composts used were prepared from two different raw materials: grape marc and a mixture of grape marc, goat manure, leaves and alfalfa. The experiment was carried out in seedling trays, in a split plot design with two factors (fertilization and substrate) and four repetitions. Sand were used as control and a commercial substrate as traditional treatment. Results indicated that fertilization had not significant effect on germination, but increased seedling biomass. Both compost also increased lettuce biomass, with the highest values obtained in mixture compost treatments. Only sand produced the lowest germination values, while no differences were detected among the other substrates. Compost mixture showed the highest seedling biomass, suggesting a higher quality as a plant substrate. It is necessary to perform further analyses and studies with different organic residues in order to determine physico-chemical and biological properties to evaluate the quality of the product obtained.

Keywords

composting • goat manure • split plot • germination index

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Resumen

El compostaje permite reducir y reciclar residuos orgánicos, generando un producto apto para ser utilizado como sustrato para el crecimiento de plantines florales y hortícolas o como enmienda de suelos. En el presente trabajo, se evaluó el efecto del compost elaborado a partir de orujo de uva agotado y de una mezcla de orujo, guano de cabra, hojas y alfalfa, sobre la germinación y biomasa de plantines de *Lactuca sativa* var Grand rapids, con y sin fertilización. Se trabajó en bandejas de siembra con un diseño de parcelas divididas con dos factores (sustrato y fertilización), utilizando, arena como control y un sustrato comercial como tratamiento tradicional. Los resultados indicaron que la fertilización no tuvo efecto significativo sobre la germinación, obteniéndose los menores valores con la arena, sin encontrarse diferencias entre el resto de los sustratos. Por otro lado, ambos tipos de compost produjeron mayor biomasa que el sustrato comercial y la arena, efecto que se incrementó con la fertilización. El compost mezcla fue el sustrato que produjo el mayor crecimiento de plantines de lechuga, lo que indicaría una mayor calidad para ser utilizado como sustrato. Es necesario continuar con estudios para determinar las propiedades fisicoquímicas y biológicas del compost que permitan evaluar la calidad de producto obtenido.

Palabras clave

compostaje • guano de cabra • parcelas divididas • índice de germinación

Introduction

In central western Argentina, viticulture is one of the most important agricultural activities, with a production of 11.8 million hL of wine in 2017 in Cuyo region (www.inv.gov.ar). However, as a result of this activity, around 500 t of solid effluent are generated every 23,000 hL year^{-1} of wine produced, consisting mainly of stalks, marc, flock and sludge (12).

The composting process makes it possible to reduce and stabilize organic waste and it is even possible to degrade some contaminants such as pesticides, herbicides and chemicals into less toxic substances (16), while eliminating pathogens in the thermophilic stage (14). It is an aerobic biological process by which biodegradable organic waste is transformed into a homogeneous rich in nutrients material, which can be used as plant substrate and soil amendment (6, 9, 11). There are different large-scale processing systems but the most commonly used at the farm level are those of piles or rows, static or aerated. In the latter case performing periodic turning manually or by means of machinery, obtaining a stabilized product with suitable physicochemical and biological properties make it useful as a soil amendment and as a substrate.

Composting is an interesting and useful proposal for recycling a large volume of organic waste generated by the distillery activity. Carmona *et al.* (2012) indicated that compost obtained from this waste can be used, under a correct irrigation and fertilization management, for plant seedling productions. The objective of this work was to evaluate the performance of the compost obtained from spent grape marc and a mixture of spent grape marc, goat manure, leaves and alfalfa, with and without fertilization, as substrate for lettuce germination and seedling production.

Materials and methods

Compost was made in aerated piles of approximately 3 m^3 (2 m length, 1.8 m width, and 0.8 high), with no cover, periodically turned every 30 days.

Two raw materials were used: spent grape marc (skins, seeds, stalks, stems and stalks from grape), and a mixture of spent grape marc, goat manure, leaves and alfalfa, in a volume proportion 1:1:3:0.5 respectively.

The piles were located in Estación Experimental Agropecuaria Mendoza, Instituto Nacional de Tecnología Agropecuaria (EEA Mendoza-INTA, 33°00'38" S, 68° 50'59" W at 921 m a. s. l.).

Under greenhouse condition (T≈ 22°C), 55 x 28 cm sowing trays, with 171 speedling cells, one *Lactuca sativa* var Grand rapids seed was placed in each cell at a depth of 2 mm and they were periodically irrigated every 48 h.

Eight treatments with four replicates were performed in a randomly distributed split plots design.

Two factors were evaluated: fertilization as a major plot, with two levels: fertilized (+F) and no fertilized (-F), and substrate as a minor plot, with four levels: sand (S), commercial substrate (K, Kekkilä® DSM 1, Professional, Finland,), grape marc compost (GMC), and mixture compost (MC, table 1). Sand was used as a control substrate and the commercial substrate as a traditional treatment.

In the +F treatments, 5 mL per plot of substrate of a 0.25% nutrient solution (KSC® 2 NPK 23-5-5-5, Timac Agro USA) were applied weekly by spraying. In each plot, 28 and 10 units of measurement were utilized to evaluate germination and seedling production respectively.

Table 1. Physico-chemical properties of compost (1:5 v/v water suspension) and commercial substrate (Kekkilä®) used in germination and seedling production assay.

Tabla 1. Propiedades fisicoquímicas del compost (suspensión en agua 1:5 v/v) y del sustrato comercial (Kekkilä®) utilizado para los ensayos de germinación y producción de plantines.

Compost	pH	EC	C:N	NH_4^+	NO_3^-	ρ_{app}	PA
		(dS m^{-1})		(mg kg^{-1})		kg L^{-1}	%
Kekkilä®	5.9	0.2	-	-	-	0.09	90
GMC	6.50 ± 0.16	1.16 ± 0.33	17.91 ± 0.16	34,89 ± 11.67	5.22 ± 1.74	0.36 ± 0.01	29.41 ± 2.35
MC	7.79 ± 0.10	1.23 ± 0.03	14.42 ± 0.82	52.36 ± 42.67	9.71 ± 2.73	0.38 ± 0.00	31.72 ± 0.64

Physico-chemical properties of compost (1:5 v/v water suspension) and commercial substrate (Kekkilä®) used in germination and seedling production assay. EC: electrical conductivity; ρ_{app}: apparent density; PA: porous with air; GMC: grape marc compost; MC: mixture compost.

Propiedades fisicoquímicas del compost (suspensión en agua 1:5 v/v) y del sustrato comercial (Kekkilä®) utilizado para los ensayos de germinación y producción de plantines. EC: conductividad eléctrica; ρ_{app}: densidad aparente; PA: poros con aire; GMC: Compost de orujo de uva; MC: compost mezcla.

Germination was evaluated determining Total Germination (TG), Medium Time Germination (MTG, 3) and Emergency Rate Index (13):

$$MTG = \frac{\sum D * n}{\sum n}$$

where:

n = number of germinated seeds on a day D

D = number of days recorded since the beginning of germination

$$ERI = \sum \mathrm{Xn\ (c\text{-}n)\ /\ N}$$

where:

Xn = number of germinated seeds counted on day n

c = number of days from sowing to emergency end

n = day on which the emergency begins expressed as number of days after sowing

N = total number of germinated seeds.

To evaluate seedling biomass production in each treatment, total dry weight (DW, at 70°C for 48 hours) of 60 days old plants was determined for each treatment.

The effect of the factors on germination seedling biomass was evaluated by ANOVA with split plot model and LSD Fisher mean comparison test (p≤0.01). In order to determine differences among treatments, beside standard error for media estimation, a single standard error of ANOVA (SE_{ANOVA}) for each variable analyzed was considered. For this purpose, InfoStat software version 2015 was used (InfoStat Group, FCA, National University of Córdoba, Argentina).

Results

Effect of compost on germination

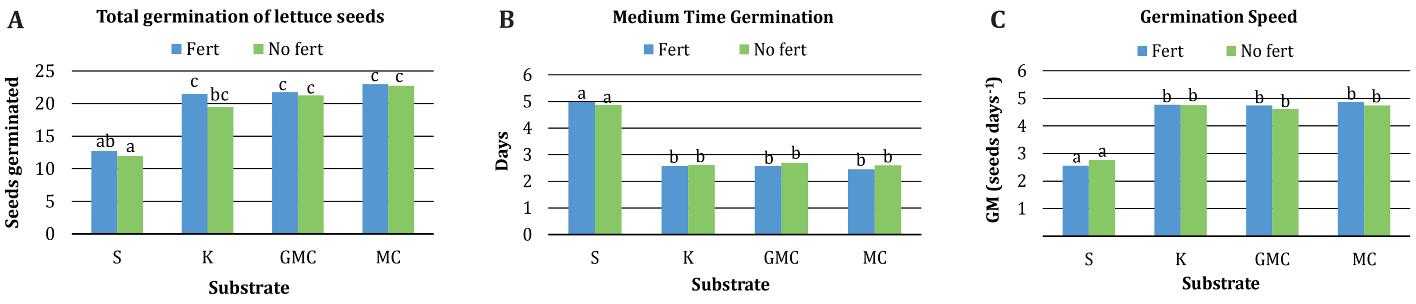
Compost had a positive effect on the germination of lettuce plants, In both GMC and MC, TG of seeds was significantly higher than S, and no different from K (figure 1A, page 265). MC reached the highest values of 23.00 ± 0.91 and 22.75 ± 0.95, GMC of 21.75 ± 0.48 and 21.25 ±2.17, K of 21.50 ± 2.10 and 19.50 ± 0.50, and S of 12.75 ±1.89 and 12.00 ±2.35 germinated seeds, respectively for +F and -F (SE_{ANOVA}: ± 2.25).

Although with +F treatments a greater quantity of germinated seeds was obtained, there were no significant differences with respect to those -F. These results suggest that the factor that most influenced the germination was the substrate, with no significant effect of fertilization (p≤0.01).

The MTG was determined mainly by the substrate, with no interactions and no significant effect of fertilization (figure 1B, page 265).

Compost and commercial substrate treatments (MC: 2.57 ± 0.06 and 2.70 ± 0.11; GMC: 2.45 ± 0.19 and 2.60 ± 0.07; K: 2.57 ± 0.15 and 2.62 ± 0.07 days, respectively for + F and -F) showed significantly lower values than S (4.98 ± 0.27 and 4.87 ± 0.58 days, SE_{ANOVA}: ± 0.29).

In ERI, results were opposite to those observed in the germination time. MC, GMC and K (4.74 ± 0.36 and 4.62 ± 0.50; 4.87 ± 0.19 and 4.74 ± 0.10; 4.77 ± 0.18 and 4.75 ± 0.09 seeds germinated per day, respectively for +F and -F) presented significantly higher values with respect to S (2.56 ±0.36 and 2.76 ± 0.50 seeds germinated per day, SE_{ANOVA}: ± 0.31, figure 1C, page 265).



Graph A: Total germination of lettuce seeds; graph B: Medium time germination expressed as days from sowing based on Bewley and Black (1986); graph C: Emergency Rate Index, expressed as number of seeds germinated per day (Shmueli and Goldberg 1971). Split plot ANOVA was performed, with LSD Fischer comparison ($p<0.01$).

A: Germinación total de semillas de lechuga; B: Tiempo Medio de Germinación, expresados en días desde la siembra (Bewley and Black 1986); C: índice de la Tasa de Emergencia, expresado como número de semillas germinadas por día (Shmueli and Goldberg 1971). Se realizó un ANOVA con un modelo de parcelas divididas y comparación LSD Fischer ($p<0,01$).

Figure 1. Germination and plant emergency of *Lactuca sativa* var Grand rapids seeds in different substrates: Sand (S), Commercial substrate (K), Grape Marc Compost (GMC), Mixture Compost (MC: grape marc, goat manure, leaves and alfalfa).

Figura 1. Germinación de semillas de *Lactuca sativa* var Grand rapids en diferentes sustratos: Arena (S), Sustrato comercial (K), Compost de orujo de uva (GMC), Compost mezcla de residuos (MC: orujo de uva, guano de cabra, hojas y alfalfa).

Effect of compost on plant biomass

The dry weight of lettuce seedlings was significantly affected by the interaction substrate*fertilization.

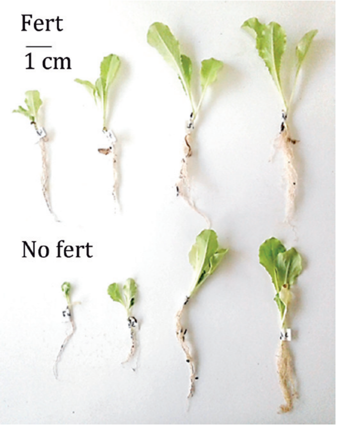
The MC+F treatment (101.93 ± 2.81 mg) was significantly superior to the rest of the treatments, followed by GMC + F and MC-F (88.80 ± 2.16 and 82.83 ± 2.50 mg respectively), which were not differentiated from each other, and by GMC-F and K+F that showed similar values (68.58 ± 2.86 and 61.58 ± 2.86 mg respectively, SE_{ANOVA}: ± 2.1).

In general and in each substrate, the average values were higher in + F than - F treatments, being the seedlings belonging to both types of compost the ones that presented higher biomass (figure 2).

Discussion

The results indicated that the compost could be used as a substrate for growing lettuce seedlings in sowing trays. Both compost exhibited higher germination values than sand and similar to commercial substrate, and lettuce biomass was also higher in compost treatments, with higher values in mixture.

According to Beltrán Santoyo *et al.* (2017), Bernal *et al.* (2009) and Moral *et al.* (2009), the use of different types of waste, especially manures, would enrich and improve the biological and physicochemical properties of compost, obtaining a higher quality product to be used as a substrate or soil amendment.



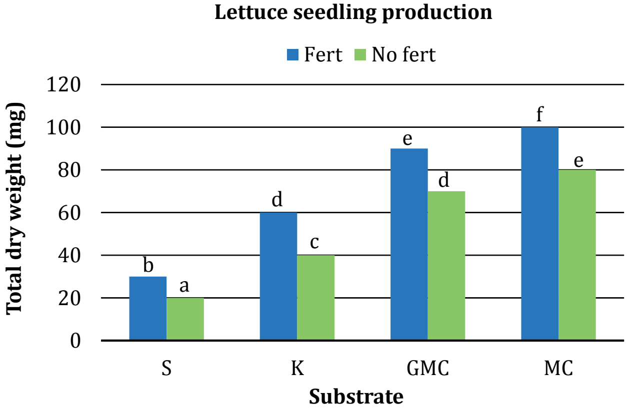


Figure 2. *Lactuca sativa* var Grand rapids seedlings production in different substrates: Sand (S), Commercial substrate (K), Grape Marc Compost (GMC), Mixture Compost (MC: grape marc, goat manure, leaves and alfalfa). Split plot ANOVA was performed, with LSD Fischer comparison (p<0.01).

Figura 2. Producción de plantines de *Lactuca sativa* var Grand rapids en diferentes sustratos: Arena (S), Sustrato comercial (K), Compost de orujo de uva (GMC), Compost mezcla de residuos (MC: orujo de uva, guano de cabra, hojas, y alfalfa). Se realizó un ANOVA con un modelo de parcelas divididas y comparación LSD Fischer (p<0,01).

In general, fertilization produced an increase in plant biomass but had no effect on the germination of lettuce plants. This suggested that the use of fertilizers is not necessary during germination, where the seed would mainly use its own reserves, but would have a positive effect on growth and development stages.

However, it is important to note that both unfertilized compost had higher biomass values than commercial substrate and sand with fertilization, and the compost mix was significantly higher. This could be given by the nutritional contribution of the compost from the different raw materials, being sufficient for an optimal plant development.

Baran *et al.* (2001) indicated that grape marc compost should be blended with other substrate for optimal results, and in agree with that it was founded that composting with other residues produce a higher quality product.

Composting process allows treating and reducing large volumes of organic waste.

In the case of the wine industry, a stable, nutritious and sanitized product can be obtained from spent grape marc, with excellent properties to be used as a substrate for potted plants (7, 17).

The application of this methodology on a large scale would generate environmental and economic benefits for the industry, through waste treatment and emission reduction, and for producers and nurseries, by accessing a product with superior properties in comparison with commercial, more expensive substrates and fertilizers (13).

Based on the residues used, to evaluate physicochemical and biological characteristics of compost, becomes necessary studying composting process alternatives, determining the content and availability of micro and macronutrients, and the microflora that benefits plant growth.

Finally, and according to Luo *et al.* (2018), it is important to determine the quality of compost that would be used as a commercial substrate or soil amendment, evaluating different proportions, with different plant species and production systems.

Conclusion

Composting is a waste treatment alternative that generates a suitable product to be used as substrate for germination and growth of lettuce plants.

Mixture of different organic waste, especially goat manure, would generate a product of higher nutritional quality that would not require additional fertilization for crop production.

Both, GMC and MC, presented adequate characteristic for lettuce plants growing, surpassing the commercial substrate, offering the producer a cheaper and more efficient alternative for the production of different vegetable seedlings.

Composting is an adequate alternative to reduce and treat industrial organic residues.

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