

## Food Source and Inoculation Density in the Rearing of Earthworms (*Eisenia Foetida*) in Cuzco, Peru

Fuente Alimenticia Y Densidad De Inoculación En La Crianza De Lombriz (*Eisenia Foetida*) En Cuzco, Perú

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### Abstract

The effect of food source and inoculation density on the rearing of the red California earthworm (*Eisenia foetida*) in Cuzco, Peru, was evaluated. A completely randomized design (CRD) was used, with AxB factorial arrangement, with twelve treatments and two replications, making a total of 24 experimental units (EU). Factor A was the food source, with four levels (a1=bovine compost, a2=sheep compost, a3=guinea pig compost and a4=alpaca compost) and factor B was the inoculation density, with three levels (b1=200 worms/EU, b2=400 worms/EU and b3=600 worms/EU) of clitellated (sexually mature) worms. The EU were wooden beds of 0.4 m length, 0.4 m width and 0.2 m height, with a capacity of 32 L. First, 25 kg of compost from each food source was incorporated into each wood bed, and then inoculated with the worms at the density corresponding to each treatment and EU, respectively. After 90 days, the biological dynamics and yield were evaluated. It was determined that the alpaca and sheep compost showed a greater capacity for biological development (number of cocoons, juvenile and adult worms) and productive capacity (worm weight and humus conversion). In inoculation density, level b3 (600 worms/UE) was outstanding in the biological dynamics of the earthworm; however, in humus production, although there were significant differences ( $p>0.01<0.05$ ) between the levels, this was not greater than 3%.

**Key words:** manure, compost, bedding, inoculation, reproduction, humus.

### Resumen

Se evaluó el efecto de la fuente alimenticia y densidad de inoculación en la crianza de la lombriz roja californiana (*Eisenia foetida*) en Cuzco, Perú. Se utilizó el diseño completamente al azar (DCA), con arreglo factorial de AxB, con doce tratamientos y dos repeticiones, haciendo un total de 24 unidades experimentales (UE). El factor A fue la fuente alimenticia, con cuatro niveles (a<sub>1</sub>=compost de vacuno, a<sub>2</sub>=compost de ovino, a<sub>3</sub>=compost de cuy y a<sub>4</sub>=compost de alpaca) y el factor B fue la densidad de inoculación, con tres niveles (b<sub>1</sub>=200 lombrices/UE, b<sub>2</sub>=400 lombrices/UE y b<sub>3</sub>=600 lombrices/UE) de lombrices cliteladas (maduras sexualmente). Las UE fueron lechos de madera de 0,4 m de largo, 0,4 m de ancho y 0,2 m de altura, con una capacidad de 32 L. Primeramente en cada lecho de madera, se incorporó 25 kg del compost de cada fuente alimenticia, para posteriormente inocular con las lombrices en la densidad correspondiente a cada tratamiento y UE respectivamente. A los 90 días se evaluó la dinámica biológica y el rendimiento. Se determinó que el compost de alpaca y de ovino demostraron mayor capacidad de desarrollo biológico (número de cocones, lombrices juveniles y adultas) y capacidad productiva (peso de lombrices y conversión de humus). En la densidad de inoculación sobresalió el nivel b<sub>3</sub> (600 lombrices/UE) en la dinámica biológica de la lombriz; sin embargo en la producción de humus, si bien hubo diferencias significativas ( $p>0,01<0,05$ ) entre los niveles, esta no fue superior al 3%.

**Palabras clave:** Estiércol, compost, lecho, inoculación, reproducción, humus

## Introduction

Climate change is becoming an increasingly visible and palpable threat, as it directly influences local climate variability and indirectly influences the availability of natural resources, with an emphasis on poverty (Intergovernmental Panel on Climate Change IPCC, 2001 and 2007, cited by Cuellar and Salazar, 2016). The Andes have shown greater sensitivity, favoring soil erosion processes, loss of vegetation cover, rainfall variability, alteration in crop dynamics, etc. (Lozano *et al.*, 2021). This has led to the need for a change towards a more sustainable agricultural model (Bedoya and Julca, 2021) that is in line with environmental quality, whose main problem is not to achieve high yields, but long-term stabilization (Altieri, 1999), where the soil is the basis of its productivity, in this sense, soil conservation is an essential task (Sáenz, 2020). Likewise, soil organic matter (OM) is an essential constituent of the edaphic system, since due to its constitution and properties it is directly responsible for most of the soil physicochemical and biological processes (Raison and Rab, 2001, cited by Medina *et al.*, 2017; Trinidad and Velasco, 2016); it is a crucial element for the regulation of many processes related to agricultural productivity (Martínez, 2019). The application of OM to soil provides an integrative effect, which promotes soil health and quality, with a preventive approach to agricultural management, improving soil properties in order for the agroecosystem to be self-regulating, self-sufficient, resistant to degradation and resilient (Céspedes and Millas, 2015; Martínez, 2017; Collantes *et al.*, 2019; Jiménez *et al.*, 2019). An alternative for the addition of OM to the soil is the incorporation of earthworm humus or vermicompost; high quality organic fertilizer, due to the benefits of its application to the soil (Damian *et al.*, 2018; Sarmiento *et al.*, 2019).

Vermiculture is a clean and easy to apply process to recycle biodegradable waste, producing a high-quality compost (Schuldt, 2006; Romero *et al.*, 2015; Gutiérrez *et al.*, 2020). It is a zootechnical activity, easy to integrate into agricultural systems (Rodríguez, 2005; Romero *et al.*, 2015). *Eisenia foetida*, known as the Californian red earthworm, is the most widespread species in the practice of vermiculture (Reines *et al.*, 1998), given its hardiness, tolerance to environmental factors, reproductive potential and capacity for crowding, living in captivity and without escaping (Rodríguez, 2005). Worms are microphagous, feeding on bacteria, protozoa, microalgae and fungi, which they ingest with the substrate. This conglomerate of organisms is abundant in properly matured animal manures (Limachi, 2018), which is why they constitute the essential basic medium for initiating a worm culture (Schuldt, 2006). The digestion of OM by earthworms results in an organic fertilizer called humus (Gutiérrez, *et al.*, 2020). The amount of humus that can be produced in a given area and time is related, among other factors, to the earthworm stocking density (Schuldt, 2006). Likewise, the yield of vermicompost can be variable, because the characteristics of the substrate directly affect the state and multiplication of this organism, since they depend to a great extent on the type and quality of the food, so the effect of the food sources on the population dynamics and productive capacity of the earthworms must be known (Durán and Henríquez, 2009). Therefore, the objective of this research was to evaluate the food source and inoculation density in the rearing of the red California earthworm (*Eisenia foetida*) in Cuzco, Peru.

## Materials and Methods

The research was conducted at the Universidad Nacional de San Antonio Abad del Cusco (UNSAAC), located in the district of San Jerónimo, province and department of Cusco, at an altitude of 3225 masl, geographic coordinates 13°33'11.10" S and 71°52'29.33" W, and UTM coordinates 8'499 994.02 N and 188 844.83 E. The area has two well-marked climatic seasons: rainy (November-March) and dry (April-October), with January being the month with the highest rainfall (156.32 mm/month). The highest temperature (21.7 °C) occurs in October, while the lowest temperature (-1.6 °C) occurs in July (Paucar *et al.*, 2018; Servicio Nacional de Meteorología e Hidrología del Perú [SENAMHI], 2018).

A completely randomized experimental design (CRD) was used, with AxB factorial arrangement, making a total of 12 treatments and two replications (Table 1).

**Table 1.** Factors, levels and treatments studied.

Factor A	Factor B	Treatments
Food source	Inoculation density	
Levels	Levels	
a1: Beef compost	b1: 200 units/EU	T1
	b2: 400 units/EU	T2
	b3: 600 units/EU	T3
a2: Sheep compost	b1: 200 units/EU	T4
	b2: 400 units/EU	T5
	b3: 600 units/EU	T6
a3: Guinea pig compost	b1: 200 units/EU	T7
	b2: 400 units/EU	T8
	b3: 600 units/EU	T9
a4: Alpaca compost	b1: 200 units/EU	T10
	b2: 400 units/EU	T11
	b3: 600 units/EU	T12

EU: Experimental unit.

In the preparation of the compost, cattle, sheep, alpaca and guinea pig manure was used, in addition to quinoa harvest stubble, agricultural soil, ash and water; the proportion of quinoa stubble in relation to the manure was 50%. The procedure consisted of incorporating a layer (30 cm) of quinoa stubble, on top of which a layer of manure (30 cm) was added, on top of which farmland and ashes were sprinkled, and then moistened and covered with plastic. After 15 days, the first turning was carried out. From that moment on, this work was repeated weekly, at room temperature, for a period of 60 days.

The rearing beds were made of wood. Each bed constituted an experimental unit (EU), whose dimensions were 0.4 m long, 0.4 m wide and 0.2 m high, with a capacity of 0.032 m<sup>3</sup> (32 L). For the inoculation of the worms, 25 kg of compost was first incorporated into each UE. Subsequently, the worms were inoculated at the density corresponding to each treatment, where the worms that were inoculated had a developed and visible clitellar ring, a sign of sexual maturity (Durán and Henríquez, 2009). The UE were also covered with raschel mesh, and to guarantee adequate biological conditions, humidity and temperature were controlled.

At 90 days, 500 g samples were taken from each EU and the biological dynamics and yield were evaluated. Analyses of variance (ANVA) were performed with the corresponding data, and when the sources of variation in the ANVA were significant, comparisons of treatment averages were made using Tukey's test (0.05).

## Results and Discussion

### Biological dynamics

#### Number of coconuts

No differences ( $p > 0.05$ ) were determined in the source of variation of the interaction of the AxB factors. However, for factor A, differences ( $p < 0.01$ ) and differences ( $p > 0.01 < 0.05$ ) were found for factor B; therefore it is necessary to apply Tukey (0.05) to determine the difference between the averages of the levels of factors A and B respectively, due to the non-significance of the interaction of the AxB factors (Gabriel et al., 2021); where the alpaca and ovine compost reached averages of 119 and 104 coconuts respectively, surpassing the guinea pig and bovine compost, which achieved averages of 58 and 56 coconuts respectively; likewise the density of 600 and 400 earthworms/EU reached averages of 94 and 83 coconuts, respectively, surpassing the density of 200 earthworms/EU which achieved an average of 75

coconuts.

### Number of juveniles

The sources of variation of factors A, B and AxB were significant ( $p < 0.01$ ). When performing the ANOVA of simple effects of AxB (Gabriel, 2021), differences were found ( $p < 0.01$ ) in factor A with respect to the levels of factor B ( $b_1$ ,  $b_2$  and  $b_3$ ). In the case of factor B for each level of factor A, differences ( $p < 0.01$ ) were obtained in levels  $a_2$ ,  $a_3$  and  $a_4$ ; however, for level  $a_1$  no differences ( $p > 0.05$ ) were determined. When applying Tukey (0.05), for the number of juveniles, significant differences were observed for the food sources (Factor A) when combined with the different inoculation densities, the highest average being found in the combination  $a_4b_2$  (alpaca compost and 400 worms/UE) with 175 juveniles. Similarly, for Factor B (inoculation densities) differences were determined when combined with the different levels of food sources, achieving the highest average  $b_3a_4$  (600 worms/UE and alpaca compost) with 175 juvenile worms (Table 2). Durán and Henríquez (2009) mentioned that the size of the individuals and the reproductive rate are influenced by the type of substrate, of which the alpaca and ovine substrate offered better conditions for worm reproduction. However, this contrasts with the statement of Baltierra (2003) that population density did not show a significant effect ( $p > 0.05$ ) on the number of cocoons and number of young earthworms for *Eisenia sp.*

**Table 2.** Tukey's test (0.05) for the simple effects of factor A at each level of factor B; and the simple effects of factor B at each level of factor A, on the number of juveniles.

Factor		Average	Factor		Average
A	B	g	B	A	g
a4	b1	83a	b3	a2	122a
a2	b1	64a	b2	a2	116a
a3	b1	20b	b1	a2	64b
a1	b1	5b	b3	a3	110a
a4	b2	175a	b2	a3	61b
a2	b2	116b	b1	a3	20c
a3	b2	61c	b3	a4	175a
a1	b2	20c	b2	a4	164a
a4	b3	164a	b1	a4	83b
a2	b3	122 b			
a3	b3	110 b			
a1	b3	22 c			

A: Food source, B: Inoculation density

a1: Cattle compost, a2: Sheep compost, a3: Guinea pig compost, a4: Alpaca compost

b1: 200 earthworms/EU, b2: 400 earthworms/EU, b3: 600 earthworms/EU

Equal letters within columns are statistically similar ( $p > 0.05$ ).

### Number of adults

There were no differences ( $p > 0.05$ ) in the AxB interaction. However, for A and B, differences were found ( $p < 0.01$ ). When applying Tukey (0.05) for A and B, it was determined that the best food sources were alpaca and ovine compost, reaching 27 and 25 adults, respectively. Likewise, with the inoculation density of 600 worms/EU, 30 adults were achieved. The results observed show that alpaca compost offered better conditions for the development of earthworms, followed by sheep compost, which would be related to the lower salt content of alpaca compost (1.89 dS/m), compared to sheep compost (2.21 dS/m), guinea pig compost (3.51 dS/m) and cattle compost, which is the most saline (6.46 dS/m). Durán and Henríquez (2009) mention that high pH and EC values produce stress conditions and have a negative effect on fecundity, with a decrease of up to 25% in the reproduction rate. Regarding inoculation density, it was observed that the greater the number of inoculated individuals, the higher the reproduction rate.

### Length and weight of worm

In none of the sources of variation of the ANOVA, differences were determined ( $p>0.05$ ). However, averages of 8.6 to 9.2 cm of worm length were observed, which coincides with Cabrera (2006), who affirms that adult worms reach between 8-10 cm in length and 3-5 mm in diameter. In the case of worm weight, no differences were found ( $p>0.05$ ) for factors A and B, as well as for the AxB interaction, which shows that the food source and inoculation density did not influence the weight of the worms; However, average weights of 0.79 to 0.84 g were achieved, which is within the range reported (0.3-1.4 g) by Schuldt (2006) and higher (0.34-0.66 g) than that reported by Durán and Henríquez (2009).

### Production

#### Yield of earthworms

No differences ( $p>0.05$ ) were determined in AxB. However, for A and B, differences were found ( $p<0.01$ ). When applying Tukey (0.05) for A and B, it was determined that alpaca and sheep compost achieved yields of 24 and 21 g, respectively. For inoculation density, it was found that 600 worms/EU achieved a yield of 25 g (Table 3).

**Table 3.** Tukey's test (0.05) for worm yield in factors A and B.

Food source	Average (g)	Inoculation density	Average (g)
a4	24a	b3	25a
a2	21ab	b2	19b
a1	18b	b1	13c
a3	13c		

A: Food source, B: Inoculation density

a1: Cattle compost, a2: Sheep compost, a3: Guinea pig compost, a4: Alpaca compost

b1: 200 earthworms/EU, b2: 400 earthworms/EU, b3: 600 earthworms/EU

Equal letters within columns are statistically similar ( $p>0.05$ ).

This shows that the alpaca compost favored the yield of earthworms over the rest of the evaluated composts. Likewise, for the inoculation density factor, at 45 days a dominance of level a3 (600 worms/EU) was found, which shows that the higher the number of inoculated individuals, the higher the yield; however, it should be noted that, as time goes by, the food decreases and the population increases, which brings about productive consequences, as Schuldt *et al.* (2005) state that whatever the vermiculture management strategy, the degree of earthworm crowding in the substrate has a greater influence than other factors on coconut production.

### Humus yield

Differences were determined for A ( $p<0.01$ ) and B ( $p>0.01<0.05$ ). When applying Tukey (0.05) for A and B; alpaca and sheep compost achieved humus yields of 14.94 (59.76%) and 14.22 kg (56.88%), respectively. The observed differences express the goodness of the composted alpaca manure for humus production, with the same tendency for the sheep manure compost. These results are similar to other research such as that carried out by Rodríguez (2005), who reports conversions of 48.52% (using pseudo plantain stems); Chura (1999), cited by Enríquez and Soto (2017) who used bovine, equine, camelid, sheep and goat manure and reports a yield of 49 to 57%; although they are higher than those reported by Sánchez (2003) who reports 26% and 23%, using mixed semi-composted plantain and cachaza harvest by-products. Likewise, the inoculation density of 600 worms/EU achieved a yield of 12.58 kg (50.32%), surpassing the density of 400 and 200 worms/EU that achieved 12.18 (48.72%) and 11.88 kg (47.52%) of humus, respectively (Table 4).

**Table 4.** Tukey's test (0.05) for humus yield in factors A and B.

Food source	Average (kg)	Conversion (%)	Inoculation density	Average (kg)	Conversion (%)
a4	14,94a	59,76a	b3	12,58a	50,32a

a2	14,22a	56,88a	b2	12,18b	48,72b
a1	10,20b	10,20b	b1	11,88b	47,52b
a3	9,50b	38,00b			

A: Food source, B: Inoculation density

a1: Cattle compost, a2: Sheep compost, a3: Guinea pig compost, a4: Alpaca compost

b1: 200 earthworms/EU, b2: 400 earthworms/EU, b3: 600 earthworms/EU

Equal letters within columns are statistically similar ( $p > 0.05$ ).

## Conclusions

The alpaca and ovine composts showed a greater capacity for biological development in number of cocoons, juvenile and adult worms; likewise, in productive capacity, they achieved a greater yield in worm weight and 58.27% humus conversion. In biological dynamics and humus production, the inoculation density of 600 worms/EU was outstanding. The results obtained show that it is possible to use local inputs such as alpaca and sheep manure, stubble from quinoa harvesting, among other biodegradable residues, as food sources for the development of vermiculture and to produce humus, a high-quality organic fertilizer, which can be used to incorporate into Andean soils and develop a more sustainable agriculture.

## References

1. Altieri, M. (1999). *Agroecología: Bases científicas para una agricultura sustentable*. Montevideo, Uruguay: Nordan-Comunidad. Retrieved from: <https://bit.ly/32XMMLf>
2. Baltierra, F. (2003). *Capacidad reproductiva de la lombriz de tierra (Eisenia sp.) en una unidad vermícola* (Tesis Ingeniero en Agrobiología). Universidad Autónoma Agraria Antonio Narro, Coahuila, México. Retrieved from: <https://bit.ly/3dyuBk0>
3. Bedoya, E. & Julca, A. (2021). Sustentabilidad de las fincas de palto (*Persea americana* Mill.) en la región Moquegua, Perú. *Revista RIVAR (Santiago)*, 8(22), 36-50. Doi: <https://doi.org/10.35588/rivar.v8i22.4770>
4. Cabrera, J. (2006). *Manual de lombricultura*. Cochabamba, Bolivia: Programa de apoyo a la estrategia de desarrollo alternativo en el Chapare (PRAEDAC). Retrieved from: <https://bit.ly/3cOIX1y>
5. Céspedes, C. & Millas, P. (2015). *Relevancia de la materia orgánica del suelo* (Boletín 308). Chillán, Chile: Instituto de Investigaciones Agropecuarias (INIA). Retrieved from: <https://bit.ly/3cQgwiL>
6. Collantes, R., Rodríguez, A., Beyer, A. & Rodríguez, P. (2019). Alternativas sostenibles de manejo de residuos de cosecha en agroecosistemas de palto y mandarina en Cañete, Lima, Perú. *Aporte Santiaguino*, 12(2), 228-235. Doi: <https://doi.org/10.32911/as.2019.v12.n2.644>
7. Cuellar, J. & Salazar, E. (2016, octubre). *Dinámica del carbono almacenado en los diferentes sistemas de uso de la tierra del Perú; base para una estrategia de mitigación ante el cambio climático*. Artículo presentado en XII Congreso Nacional Forestal – CONAFOR, Lima, Perú. Retrieved from: <https://bit.ly/3u5f8yN>
8. <https://bit.ly/3u5f8yN>
9. Damian, M., Gonzáles, F., Quiñones, P. & Terán, J. (2018). Plan de enmiendas, yeso agrícola, compost mejorado y enriquecido con EM y humus de lombriz, para mejorar el suelo. *Arnaldoa*, 25(1), 141-158. Doi: <http://doi.org/10.22497/arnaldoa.251.25109>
10. Durán, L. & Henríquez, C. (2009). Crecimiento y reproducción de la lombriz roja (*Eisenia foetida*) en cinco sustratos orgánicos. *Agronomía Costarricense*, 33(2), 275-281. Retrieved from: <https://bit.ly/3gNG2rp>
11. Enríquez, L. & Soto, R. (2017). *Evaluación de la producción y composición química de humus de lombriz roja californiana (Eisenia foetida) con el contenido ruminal en el camal municipal de Huancavelica* (Tesis Ingeniero Zootecnista). Universidad Nacional de Huancavelica, Huancavelica, Perú. Retrieved from: <https://bit.ly/3wwqD4i>
12. Gabriel, J., Valverde, A., Indacochea, B., Castro, C., Vera, M., Alcivar, J. & Vera, R. (2021). *Diseños Experimentales: Teoría y práctica para experimentos agropecuarios* (2da. Edición). Guayaquil, Ecuador: Universidad Estatal del Sur de Manabí. Retrieved from: <https://bit.ly/39IZcKN>

13. Gutiérrez, A., Solís, B., Panca, R. & Quispe, B. (2020). Crianza de *Eisenia foetida* (lombriz roja) en diferentes sustratos de desarrollo biológico. *Ecología Aplicada*, 19(2), 87-92. Doi: <http://dx.doi.org/10.21704/rea.v19i2.1559>
14. Jiménez, M., Gómez, R., Oliva, J., Granados, L., Pat-Fernández, J. & Aranda, E. (2019). Influencia del estiércol compostado y micorriza arbuscular sobre la composición química del suelo y el rendimiento productivo de maíz forrajero (*Zea mays* L.). *Nova Scientia*, 11(23), 165-197. Doi: <https://doi.org/10.21640/ns.v11i23.1957>
15. Lozano, A., Alvarez, C. & Moggiano, N. (2021). El cambio climático en los andes y su impacto en la agricultura: una revisión sistemática. *Scientia Agropecuaria*, 12(1), 101-108. Doi: <http://dx.doi.org/10.17268/sci.agropecu.2021.012>
16. Martínez, S. (2017). *Utilización de subproductos orgánicos vegetales para mejorar las propiedades físicas de suelos alterados* (Grado en Ciencias Ambientales). Universidad Miguel Hernández, España. Retrieved from: <https://bit.ly/3cS3dhM>
17. Martínez, G. (2019). Efecto de la maleza como cobertera en la fertilidad del suelo y rendimiento de nogal pecanero. *Revista mexicana de ciencias agrícolas*, 10(1), 123-130. Doi: <https://doi.org/10.29312/remexca.v10i1.1729>
18. Medina, J., Volke, V., Galvis, A. & Cortés, J. (2017). Incremento de la materia orgánica del suelo y rendimiento de mango en Luvisoles, Campeche, México. *Agronomía Mesoamericana (Costa Rica)*, 28(2), 499-508. Doi: <https://doi.org/10.15517/ma.v28i2.22236>
19. Limachi, E. (2018). Efecto de tres dosis de sustratos en la alimentación de la lombriz roja californiana (*Eisenia foetida*) con estiércol bovino y aserrín descompuesto en Sapecho, Alto Beni. *Revista APTHAPI*, 4(2), 1128-1138. Retrieved from: <https://bit.ly/3vy9UvM>
20. Paucar, L., González, C. & Yábar, E. (2018). Géneros Goniini (Díptera: Tachinidae: Exoristiinae) de Cusco, Perú: clave, descripciones y distribución. *IDESIA (Chile)*, 36(1), 91-104. Doi: <http://dx.doi.org/10.4067/S0718-34292018000100091>
21. Reines, M., Rodríguez, C., Sierra, A. & Vázquez, M. (1998). *Lombrices de tierra con valor comercial: Biología y técnicas de cultivo*. México: Universidad de Quintana Roo. Retrieved from: <https://bit.ly/3wq1A2C>
22. Rodríguez, F. (2005). *Lombricultura para pequeños emprendedores*. Argentina: Editorial La Quimera. Retrieved from: <https://bit.ly/3sT6Qd1>
23. Romero, J., Sánchez, J., Rodríguez, M. & Gutiérrez, M. (2015). Producción de vermicompost a base de rastrojo de maíz (*Zea mays* L.) y estiércol de bovino lechero. *Agro Productividad*, 8(3), 52-59. Retrieved from: <https://bit.ly/3cQiVdn>
24. Sáenz, S. (2020). *Agricultura de conservación y academia en Colombia: Experiencias desde la Universidad de La Salle*. Bogotá, Colombia: Ediciones Unisalle. Doi: <https://doi.org/10.19052/978-958-5148-50-5>
25. Sánchez, C. (2003). *Abonos Orgánicos y Lombricultura*. Lima, Perú: Editorial RIPALME. Retrieved from: <https://bit.ly/2PyBtpu>
26. Sarmiento, G., Pino, D., Mena, L., Medina, H. & Lipa, L. (2019). Aplicación de humus de lombriz y algas marinas en el cultivo de sandía (*Citrullus lanatus* Thunb.) var. Santa Amelia. *Scientia Agropecuaria*, 10(3), 363-368. Doi: <https://doi.org/10.17268/sci.agropecu.2019.03.06>
27. Schuldt, M. (2006). *Lombricultura: Teoría y práctica*. Madrid, España: Editorial Mundi Prensa. Retrieved from: <https://bit.ly/3sS7yXU>
28. Schuldt, M., Rumi, A. & Gutierrez, D. (2005). Estimación de la capacidad de porte en lombricultivos de *Eisenia fetida* (Oligochaeta, Lumbricidae) con distintas materias orgánicas. *Revista Argentina de Producción Animal*, 25, 101-109. Retrieved from: <https://bit.ly/31NMTIM>
29. Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI). (2018). *Boletines meteorológicos*. Retrieved from: <https://bit.ly/3t4hoWV>
30. Trinidad, A. & Velasco, J. (2016). Importancia de la materia orgánica en el suelo. *Agroproductividad (México)*, 9(8), 52-58. Retrieved from <https://bit.ly/3fHuhlG>