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Effect of earthworm, bovine and guinea pig humus in the yield of onion crop (*Allium cepa* L.), Perú

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Abstract
The objective of the research was to evaluate the effect of worm, bovine and guinea pig humus on the vegetative phase and yield of onion cultivation (*Allium cepa* L.) red variety Arequipeña in the district of Curpahuasi, province of Grau, department of Apurímac. In the study vegetative parts of the onion crop were measured, the methodology of the study is quantitative with a random complete block design. The results present significant differences (Sig.<0.05) reporting the highest plant height for worm humus compared to the control treatment that obtained 39.77 cm, greater number of leaves forBovinase. Bovine in the dose of 20 t/ha with 7.14 leaves compared to the control that obtained 5.39 average leaves. Production yields are expressed higher bulb height with the worm humus treatment or significant differences (Sig. > 0.05) were recorded between the average bulb weight and yield per area. Worm humus (10.8 t/ha) that induces a higher statistical average with 340 g and 58.62 t/ha and the control with 180 g and 31.92 t/ha, for the aforementioned considerations it is concluded that the application of worm humus in the dose of 10.8 t/ha in conclusion is recommended in the production of red onion Arequipeña in the climatic conditions of the district of Curpahuasi.

Keywords: Worm humus, bovine, guinea pig, vegetative phase and onion crop yield

Introduction
The onion (*Allium strain* L.) It is considered an economically important vegetable grown all over the world and used all year round, fresh and processed. Onion contains carbohydrates, vitamins, minerals, antioxidants and essential oils (Roldan *et al*., 2008) [1] and can be successfully grown in an organic production system. Organic fertilizers improve the chemical and physical properties of the onion, i.e. the content of minerals and total soluble solids (Gadelrab and Elamin, 2013) [2]. Organic fertilizers contain nutrients necessary for the growth and balanced development of plants, in addition, they also improve the physical (absorption, friability of the soil, granulometric composition), biological (biodiversity and abundance of microorganisms) and chemical properties of the soil (pH, C Org, organic matter, available forms of micro and macroelements, enzymatic activity of soil) (Zhang *et al*., 2016) [3]. This can be attributed to the increase in availability that allows onion plants, which form weak and shallow root systems, to absorb more N and effectively synthesize more chlorophylls and carotenoids (Shedeed, Sayed and Bash, 2014) [4]. Chlorophylls are one of the strong antioxidant substances in a plant kingdom. Thus, the addition of chlorophyll to the proportion of human food leads to a significant decrease in carcinogen-induced oxidative effects. (Moldovan *et al*., 2009) [5].
The onion has a good response to biofertilizers due to the morphology of the root system, so the novelty of this study is a comparison of the reaction of the onion to different biofertilizers and expand knowledge about the relationship between biofertilizer and onion quality in the following growing seasons.
In this environment, fertilization with organic sources such as earthworm humus (HL) and Cuyasa becomes a viable alternative. Numerous studies on the use of LH assert the benefits of its application to the soil, improving its physical-chemical and biological characteristics, and increasing the yields of different crops (Reyes *et al*., 2017; Damian *et al*., 2018; Wu *et al*., 2019) [7, 6, 8].

The research evaluated the effect of worm, bovine and guinea pig humus on the vegetative phase and yield of onion cultivation (*Allium cepa* L.) Red variety Arequipeña

Methods

The research was developed in the community of Colcabamba in the District of Curpahuasi-Grau-Apurímac, with a temporary space of duration of 06 calendar months. The sample population consisted of onion plants (*Allium cepa* L.) red variety Arequipeña, in a number of 3360 units, in a total area of 100.80 m2. The determination of the sample was carried out at random, because it was considered that onion plants are homogeneous throughout the process of their vegetative development

Purchase of organic fertilizers

As a first stage there was the acquisition of worm, bovine and guinea pig humus, which were fundamental to carry out the research. The organic fertilizers were made by the researcher, but this was no longer part of the research.

Application of organic Fertilisers

The dose was based on the N, P and K data from the soil analysis of the preliminary phase that was carried out and in the same way according to the requirement of the culture and the chemical composition of the worm, bovine and guinea pig humus obtained from the analysis result.

Land preparation, leveling and plot design

The preparation of the land was carried out 15 days before planting, in order to eliminate some existing pathogens and weeds, this agricultural work was done in order to leave the soil available, free of weeds and stones existing in the experimental area. Once the ground was prepared for 15 days, the experimental units were leveled and designed according to the random distribution of the treatments, in which materials such as wincha, stakes, twine, picks, rakes, shovels, sacks and other materials were used.

a) Determination of the vegetative phase

Number of leaves: this evaluation was carried out in three periods, first 30 days after transplantation, second at 60 days and third at 90 days. The evaluated date was April 30, 2020 for the number of sheets at 30 days, May 30, 2020 for the number of sheets at 60 days and June 29, 2020 for the number of sheets at 90 days. Plant length: this evaluation was performed in three periods, first 30 days after transplantation, second at 60 days and third at 90 days, a wincha was used. The evaluated date was April 30, 2020 for plant height at 30 days, May 30, 2020 for plant height at 60 days, and June 29, 2020 for plant height at 90 days.

Statistical analysis

One-way analysis of variance (ANOVA) and Tukey's multiple range test at 95% confidence were used; All outcomes were measured three times.

Results

Effect of worm, bovine and guinea pig humus in the vegetative phase of onion (*Allium cepa* L.) red variety Arequipa

In the vegetative phase of onion cultivation are determined by the height of plant and the number of leaves and to describe their behavior have been measured at 30, 60 and 90 days after planting (dds) whose results are shown below

Floor height: The data represent the averages assessed at 30, 60 and 90 (dds). Table 1 shows that during the 30 dds, the plant height reaches a maximum value of 18.60±3.22 cm with the T7 treatment. Cuyasa 18.6 t/ha and in decreasing order continue the averages of 17.89±0.19 cm, 17.66±0.69 cm, 17.30±0.99 cm for T2 treatments. Worm humus 10.3 t/ha, T3. Worm humus 10.8 t/ha and T1. Worm humus 9.8 t/ha respectively. These plant heights for 30 dds are higher than the control treatment that reports a height of 15.74±1.20 cm, which in turn, is higher than those reported by bovine-based treatments (T4, T5 and T6) that report heights of 14.45±1.24 cm, 14.11±1 cm and 14.43±2.03 cm respectively.

Table 1: Descriptive statistics of plant height at 30, 60 and 90 days after installation

Treatments	30 days		60 days		90 days	
	Stocking	Deviation Standard	Stocking	Standard deviation	Stocking	Standard deviation
T1. Earthworm humus (9.8 t/ha)	17.30	0.99	37.74	4.20	58.62	6.64
T2. Earthworm humus (10.3 t/ha)	17.89	0.19	36.87	2.67	56.10	4.09
T3. Earthworm humus (10.8 t/ha)	17.66	0.69	38.70	2.13	61.26	4.58
T4. Bovine (19.5 t/ha)	14.45	1.24	33.89	4.98	53.21	10.38
T5. Bovine (20 t/ha)	14.11	1.00	30.82	1.19	48.33	2.97
T6. Bovine (20.5 t/ha)	14.43	2.03	34.16	3.11	56.40	6.18
T7. Cuyasa (18.6 t/ha)	18.60	3.22	36.03	3.35	52.70	4.78
T8. Cuyasa (19.1 t/ha)	16.03	1.62	32.85	4.41	51.03	9.55
T9. Cuyasa (19.6 t/ha)	15.65	0.81	33.17	3.16	53.55	6.42
T10. Witness	15.74	1.20	27.54	2.80	39.77	4.43

At 60 dds, the heights of plants are reaching appreciable differences registering the highest heights in treatments based on worm humus with values of 38.70±2.13 cm, 37.74±4.2 cm and 36.87±2.67 cm, these values are significantly higher than the control treatment that registers a height of 27.54±2.80 cm. Bovine-based and guinea pigeon treatments register heights between 36.03±3.35 cm for T7. Cuyasa 18.6 t/ha and 34.16±3.11 cm for T6. Bovine 20.5 t/ha and in turn, are superior when compared with the plant height of the control treatment.

At 90 dds, the onion crop reaches its maximum height and growth stops. At this stage, the treatments based on worm

humus differ from the other treatments reaching the highest height of 61.26±4.58 cm for the T3 treatment. When the dose of 10.8 t/ha is applied, it is followed in decreasing order by bovine-based treatments that reach the highest average of 53.55±10.38 cm when the dose of 20.5 t/ha is applied, these plant heights are significantly different when compared to the average of the control that registers 39.77±4.43 cm.

Effect of worm, bovine and guinea pig humus on the yield of onion (*Allium cepa* L.) red variety Arequipa

The yield of onion production, is explained by the bulb height, bulb diameter, bulb weight and yield per surface, the data were obtained at 90 dds and the results are shown below.

Height, diameter and weight of Arequipa red onion bulb.

Table 2: Descriptive statistics of bulb height, bulb diameter and bulb weight according to treatments.

Treatments	Bulb height (cm)		Bulb diameter (cm)		Bulb weight (Kg)	
	Deviation		Deviation		Deviation	
	Stocking	Estándar	Stocking	Estándar	Stocking	Estándar
T1. Earthworm humus (9.8 t/ha)	6.54	0.36	9.05	0.32	0.29	0.01
T2. Earthworm humus (10.3 t/ha)	5.90	0.09	8.51	0.12	0.29	0.01
T3. Earthworm humus (10.8 t/ha)	6.18	0.23	9.10	0.39	0.34	0.06
T4. Bovine (19.5 t/ha)	6.03	0.31	8.55	1.31	0.30	0.10
T5. Bovine (20 t/ha)	5.78	0.29	7.76	0.55	0.33	0.15
T6. Bovine (20.5 t/ha)	5.58	0.17	7.76	0.47	0.25	0.04
T7. Cuyasa (18.6 t/ha)	6.02	0.38	7.72	0.62	0.25	0.04
T8. Cuyasa (19.1 t/ha)	6.01	0.49	7.40	0.95	0.23	0.06
T9. Cuyasa (19.6 t/ha)	6.05	0.32	7.82	0.79	0.30	0.14
T10. Witness	5.74	0.41	6.70	0.92	0.18	0.07

Bulb height

Table 2 shows the highest bulb height with 6.54 cm and a variability of±0.36 cm and corresponds to the T1 treatment. Worm humus (9.8 t/ha) and in decreasing order continues the T3 treatment. Worm humus (10.8 t/ha) with 6.18±0.23 cm after T9 treatment. Cuyasa (19.6 t/ha) with 6.05 cm, then the T7 treatment. Cuyasa (18.6 t/ha) with 6.02±0.38 cm, then the T8 treatment. Cuyasa (19.1 t/ha) with 6.01 cm it is noted that, in this treatment there is a greater variability with±049 cm, the T2 treatments. Earthworm humus (10.2 t/ha), T5. Bovine (20 t/ha) and T6. Bovine (20.5 t/ha) induce a similar effect on the height of the bulb of the onion crop with values of 5.90 cm, 5.78 cm and 5.58 cm respectively, the results of these treatments are very close to those obtained in the control treatment that registers a bulb height of 5.74 cm.

Bulb diameter

According

Table 2. Descriptive statistics of bulb height, bulb diameter and bulb weight according to treatments., the largest bulb diameters in onion cultivation are recorded in T3 treatments. Worm humus (10.8 t/ha) with the average of 9.10±0.39 cm, then T1 treatment. Worm humus (9.8 t/ha) with the average of 9.05±0.32 cm, after the T4 treatment. Bovine (19.5 t/ha) with the average of 8.55±1.31 cm, then the T2 treatment. Earthworm humus (10.3 t/ha) with 8.51±0.12 cm. T5 treatments. Bovine (20 t/ha), T6. Bovine (20.5 t/ha), T7. Cuyasa (18.6 t/ha), T8. Cuyasa (19.1 t/ha) and T9. Cuyasa (19.6 t/ha) have such an effect on the bulb diameter with values of 7.76, 7.76, 7.72, 7.40 and 7.82 cm in addition to the variability is homogeneous in these treatments, the aforementioned treatments are superior compared to the control that registers an average bulb diameter of 6.70 cm.

Bulb weight.

The weight of the bulb of the onion crop is directly related to the diameter and height of the bulb, because the larger the diameter and height of the bulb it is expected that the weight will also be greater.

According to Table

Table 2. Descriptive statistics of bulb height, bulb diameter and bulb weight according to treatments., the highest weights correspond to T3 treatments. Worm humus (10.8 t/ha) with 340 g, T5. Bovine (20 t/ha) with 330 g, T4. Bovine (19.5 t/ha) with 300 g, and in decreasing order continue T1 treatments. Worm humus (9.8 t/ha), T2. Worm humus (10.3 t/ha) with averages of 290 g followed by T6 treatments. Bovine (20.5 t/ha), T7. Cuyasa (18.6 t/ha) with an average weight of 250 g, these weights are significantly higher than the average obtained by the control treatment whose value is 180 g±0.07.

Performance per surface area

Table 1: Descriptive yield statistics by area

Treatments	Statistical	
	Stocking	Standard deviation
T1. Earthworm humus (9.8 t/ha)	50.49	1.74
T2. Earthworm humus (10.3 t/ha)	51.07	2.01
T3. Earthworm humus (10.8 t/ha)	58.62	10.20
T4. Bovine (19.5 t/ha)	52.81	16.55
T5. Bovine (20 t/ha)	57.46	26.35
T6. Bovine (20.5 t/ha)	42.95	7.25
T7. Cuyasa (18.6 t/ha)	43.53	7.59
T8. Cuyasa (19.1 t/ha)	40.63	10.64
T9. Cuyasa (19.6 t/ha)	51.65	24.64
T10. Witness	31.92	12.83

Table 1 best yields per surface are obtained by applying worm humus at a dose of 10.8 t/ha and applying bovine animals at a dose of 20 t/ha that have as effects the value of 58.62±10.20 t/ha and 57.46±26.35 t/ha of onion respectively, The treatments based on Cuyasa in its different doses show results between 40.63 t/ha to 51.65 t/ha that are lower than the yields obtained when worm or bovine humus is applied. But, when comparing with the yield obtained in the control treatment, it is observed that they are superior since in the control treatment the yield achieved was 31.92±12.83 t/ha.

Discussion

Vegetative phase of onion cultivation (*Allium cepa* L.)

The vegetative phase of onion cultivation evaluated the plant height and number of leaves, which is consistent with Mora (2015) who evaluated these variables at 30, 60 and 90 days after planting.

a) Floor height

The plant height at 30 days reaches 18.60 cm when applying cuyasa in the dose of 18.6 t/ha and at 60 and 90 dds, reached 38.70 cm and 61.26 cm with the application of worm humus at the dose of 10.8 t/ha. These findings are close to those reported by Fababa (2012) [10] who applying worm humus at the dose of 3 t/ha obtained 52.55 cm and 44.95 cm at 60 dds respectively, the growth of the onion crop ceases at 90 dds, at this time, all treatments produced increases (Sig.<0.05) with respect to the control, being the treatment T3. Worm humus (10.8 t/ha) that produced the greatest effect with 61.26 cm of height, this value is close to the value reported by Bello Moreira *et al*. (2016) [11] with a plant height of 57.9 cm for 90 days with the application of 30% biol. The measurement of plant height was measured from the base of the pseudostem to the apex of the longest leaf being the growth of the plant explained by the presence of nutrients from the organic fertilizers used, being the worm humus that has higher content of N, P 2 O $_5$ and K_2O with respect to bovine and guinea pig.

b) Number of sheets

The number of leaves in onion cultivation is directly related to the dose of application of organic fertilizers, the higher the dose is expected to be higher. At 30, 60 and 90 dds, the highest averages for T5 treatment are reported. Bovine (20 t/ha) of 3.38, 5.46 and 7.14 leaves per plant, being significant at 60 dds (Sig.< 0.05) and not significant (Sig. > 0.05) for 30 and 90 dds, the results are close to those obtained by Cáceres Ortuño & Suquilanda Valdivieso (2017) [12] who applying Bocashi (4.9 kg/m2) report 3.46 leaves at 30 days and 11 leaves for 90 dds. The number of leaves is important in the survival capacity of the crop in the field, it is related to photosynthesis that regulates the growth of roots and the translocation of photosyntates from the organs of synthesis to the reserve organs (Alvarez, Casas and Yupanqui, 2020) [13].

According to Pinzón Sandoval *et al*. (2019) [14] the content of P_2O_5 is closely related to the dynamics of dry matter accumulation and as is the case of organic fertilizers its limited content can present a reduction in the expansion of the leaf and leaf area, as well as variation in the number of leaves.

Onion crop yield (*Allium cepa* L.)

a) Height, diameter and weight of Arequipa red onion bulb

The highest bulb height was obtained with the application of worm humus (9.8 t/ha) with 6.54 cm not being significant (Sig. > 005) when compared with the other treatments evaluated, Pinzón Sandoval *et al*. (2019) [14] reported equatorial diameters [bulb heights] of 4.1 to 7.0 cm showing no significant differences between treatments, according to Cáceres Ortuño & Suquilanda Valdivieso (2017) [12] when applying an organic fertilizer increases the diameter of the polar and equatorial bulbs by 28 and 69% respectively, Bello Moreira *et al*. (2016) [11] reported that there is no statistical evidence for the length and diameter of bulbs and indicate that the highest numerical average was 7.75 cm when Biol was applied at 30% dilution.

The treatments evaluated presented two homogeneous groups in the bulb diameter being the T3 treatment. Worm humus (10.8 t/ha) that registered the highest average with 9.10 cm in contrast to the control treatment that obtained 6.7 cm the results are close to those reported by Cáceres Ortuño & Suquilanda Valdivieso (2017) [12] who indicate values between 7.1 and 9.0 cm classifying them as C1 according to the ICONTEC standard, 1994, According to the MERCOSUR Technical Regulations, onion bulbs are classified into four categories according to the transverse diameter of the bulb, with the results obtained with the worm humus treatment at a dose of 10.8 t/ha classified in category 5 (Megarejo *et al*. 2010) [15]. Both the height and diameter of the bulb is associated with the yield of onion production so that the greater the height and diameter is expected as a response, the greater the weight of the bulb, on the other hand, the relationship of the height between the diameter of the bulb is an indicator of the shape of the bulb, being the value of 1 for the round format and close to 0.5 for flattened bulbs, the results of the research show a relationship of 0.72 being considered slightly round according to (Ancco-Oliva 2016) [16].

The highest weights were obtained with T3 treatments. Worm humus (10.8 t/ha) with 340 g, T5. Bovine (20 t/ha) with 330 g and T4. Bovine (19.5 t/ha) with 300 g these averages are not significantly different (Sig. > 0.05) but are superior compared to the control that obtained 180 g. The findings are higher than those reported by Bello Moreira *et al*. (2016) [11] who registered weights of 112. 37 g to 170.28 g with the application of biol at 30%, meanwhile, Amaya-Robles & Méndez-García (2013) [17] report weights between 1010 g to 1006 g due to the effect of the combinations of nitrogen and potassium N120 x K80 and N60 x K80 respectively.

(b) Yield per area.

The yield per surface was not influenced by the treatments evaluated (Sig. > 0.05) being the treatment T3. Earthworm humus (10.8 t/ha) that obtained 58.62 t/ha compared to the control that obtained a yield of 31.92 t/ha. The result obtained is higher than that reported by Bello Moreira *et al*. (2016) [11] who through the application of 10% biol obtained yields of 43,489 t/ha and Ancco-Oliva (2016) [16] with the application of Azotobacter s.p. obtained 38,500 t/ha, Manuel Alvarez *et al*. (2020) [13] with the application of phytoregulators reports average yields of 38.51 t/ha and Cáceres Ortuño & Suquilanda Valdivieso (2017) [12] applying Bokashi report yield increase from 6.4 to 21.0 t/ha. Megarejo *et al*. (2010) [15] indicate that very early or very late harvests should be avoided. If done in advance, the growth of the leaves can continue and the bulbs take longer to dry, are lighter and can be with an open neck, wrinkled and soft, affecting the final yield.

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