Growth and Yield of Lettuce (Lactuca sativa L.) as Influenced by the Residual Effects of Guano-Char

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Derby E. Poliquit
Northwest Samar State University- San Jorge Campus
San Jorge, Samar, Philippines
derbypoliquit222@gmail.com

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***Abstract –** Biochar is one of the most important strategy to sequester much carbon in the soil. Biochar in the form of guano is not known to the farmers in the Philippines. Most of its several findings relate directly as soil amendments and little or no findings so far investigated for its residual effects on lettuce. Thus, this study aimed to determine the residual effects of guano-char (GC) on the growth and yield performance of lettuce as influenced by the remnant's material from corn. Pot experiment was laid out in a single-factorial experiment and arranged in RCBD with the following treatments: T_1-control, T_2-commercial nutrient solution (CNS), T_3-75g GC, T_4-150g GC, T_5-300g GC, T_6- 600g GC. Parameters for plant height; diameters, length and, number of leaves; volume and length of root; foliage fresh and dry weight; and yield were gathered. The results of the study indicated that GC as residue have significantly influenced the plant height; diameter, length and number of leaves; fresh and oven-dried weight of roots; and yield of lettuce 25 days after planting. The residue of 300 grams GC was found to be the optimum level because it is economically more efficient that significantly improved the lettuce growth and yield performance, though comparable with the 600 grams of GC. It considerably surpasses the effect brought about by CNS (inorganic) for almost all parameters, except; for root length and volume of lettuce. The yield achieved by 300 and 600 grams of GC is twice higher than that of CNS.*

***Keywords –** Guano char, Lettuce, Residual Effect, Pot experiment*

INTRODUCTION

Lettuce is commonly known as lechugas which is native to Southern Europe and Western Asia. In the Philippines lettuce is considered as one of the most important salad crops and also used as garnishing for other food preparations. It is rich in vitamins B-complex, K and C; foliates; thiamine; and rifoblavins [1]. It is mainly produced in the highlands of the Cordillera Administrative Region (CAR) with a higher price market value not only in the local but also in the national markets [2]. Currently, many commercial growers produce lettuce like gourmet 's farm because it is still one of the most demanded salad kits for healthier lifestyle, most especially, when it is grown organically.

Organic production of lettuce for salad is deemed important as it is eaten raw. Studies showed that lettuce can be successfully grown organically. This was confirmed by Cabilovski [3] that using Farm Yard Manure (FYM) (bat, goat and cattle manure) could yield highest profit. Among the FYM previously mentioned, bat guano is not commonly utilized by farmers due to unavailability of bat feces as it was collected inside the caves. But according to Shetty et al. [4], guano fertilizer is rich in carbon, nitrogen, vital minerals and beneficial organism which enhances soil fertility and textures. This was revealed by Slamet [5] that applying guano fertilizer as FYM provided the most excellent effect on leaves, Leaf Area Index (LAI) the rate of photosynthesis and biomass of lettuce compared to cow manure, sheep manure, green manure and compost. Charoenpakdee [6] had shown the effectiveness of guano on which guano (119 g per plant) has only slight difference of yield in lettuce as compared to commercial fertilizer (125 g per plant).

Meanwhile, guano as biochar could give a much higher results in yield of a certain crop like lettuce because biochar produced from animal origin and feedstock have higher nutrients content due to the generally higher nutrient content of animal waste as revealed by Chan et al. [7]. He further emphasized that biochar is useful resources to improve the physiochemical properties of soil, effectively maintain SOM levels, and increase fertilizer use efficiency and increase crop production, particularly for long cultivated soils in subtropical and tropical regions. Guano-char (GC) for organic production of lettuce is essential as it eliminates the presence of microorganism in the soil because lettuce was mostly consumed raw for salad. However, the influence of GC as residues for lettuce production was not yet being investigated. Thus, the limited findings/information on response of GC as residual materials to sustain and regulate nutrient uptake of soil needs further investigation, hence this study.

OBJECTIVES OF THE STUDY

The study aimed to determine response of residual effects of GC on the growth and yield performance of lettuce and also determine the optimum levels of rate of application of GC as residues.

METHODS

A. Experimental Treatment and Design

The experiment was laid out in single factor using Randomized Complete Block Design (RCBD) with three replications. The treatments were as follows;

T1= control (0 g GC/ 15 kg soil)
T2= Commercial Nutrient Solution (CNS)
T3= residue from 75 g of GC in 15 kg soil/pot
T4= residue from 150 g of GC in 15 kg soil/pot
T5= residue from 300 g of GC in 15 kg soil/pot
T6= residue from 600 g of GC in 15 kg soil/pot

The treatment control and CNS serve as determinants of significant effect derived from GC in which CNS also considered as one of the control for maximum level of effects.

B. Installation of Protective Structure

One and one-fourth meter (1.25 m) ceiling height of protective structure was made since lettuce has only shorter canopy. The frame and pole was made up of coco lumber and bamboo. Ultra Violet (UV) treated polyethylene plastic was used as roofing material because it can withstand the tearing effect brought about direct sunlight.

C. Seed Sowing and Pricking

Seeds of lettuce were sown in seed boxes filled with sterilized mixture of garden soil and vermicast at 1:1 ratio by volume. The seed boxes were placed under a protective structure with plastic polyethylene to protect the seedlings from the teardrop of the rain and direct sunlight.

The seedlings were pricked by transferring healthy individual seedlings to seedling tray upon reaching the first two true leaf stage. The seedlings were hardened by gradual sunlight exposure and regular water withdrawal until they showed signs of temporary wilting.

D. Pot Preparation

Residues of soil medium coming from pots of 1st corn cropping's at 15 kg soil were transferred to another pot and was left idled for 2 weeks. It was then divided into three portion (5 kg soil) and was filled into the 15.24 cm x 20.32 cm x 0.25 mm polyethylene bag.

E. Transplanting

A distance of 15 cm between hills x 15 cm between rows was followed prior to planting. Only healthy seedlings were considered as planting materials for sample plant.

F. Care, Management and Harvesting

Watering was done as needed by the plant according to the soil moisture content to minimize occurrence of any disease infestation of microorganisms at very wet soil condition. Weeding was done as soon as the weeds appeared. Insects were controlled by hand picking every day to minimize enough damage of lettuce foliage.

G. Data Gathered

1. Plant Height (cm)

This was done by measuring the initial height one week after transplanting and final height during harvest from the ground level up to the tip of the terminal end of the main stem using a meter stick.

2. Leaf diameter (cm)

This was obtained by getting the difference of wider portion of width of leaves (cm) from initial until final stage of growth.

3. Leaf length (cm)

This was measured by getting the length of leaves from the base of leaf blade to the uppermost part of the leaf by getting the difference of initial and final length.

4. Length of Roots (cm)

This was obtained by measuring the longest roots of the lettuce after harvest.

5. Root Weight (g)

This was be obtained by weighing the oven dried sample of lettuce root after harvest.

6. Root Volume (mL)

This was obtained through displacement method in which a water was poured to a graduated cylinder at 400 ml level as the initial reading. Roots of lettuce was then soaked. The excess water displace by the lettuce was recorded and mark as the final reading. The difference from final and initial reading was recorded as the root volume.

7. Yield

This was obtained by weighing all the plants harvested and divided by the number of plants and expressed in ton/ha.

8. Nutrient Levels Analysis for N, P, K of foliage

Both analysis was done (plant tissue and soil analysis) at PRC-RTC's Central Analytical Services laboratory, Visayas State University, Visca, Baybay City, Leyte, Philippines.

H. Data Analyses

Treatment combination of means was analyzed in ANOVA. Least significant difference between means was computed using Statistical Tool for Agricultural Research (STAR) from Plant Breeding Genetics and Biotechnology, Biometrics and Breeding Informatics (2013 version).

RESULTS AND DISCUSSION

Chemical Properties of Guano Char

The analysis of GC in Table 1. showed a moderate alkalinity level indicating more basic component but still favors growth for crops which are enriched with organic matter [8]. Above all, the GC numerically had the higher levels of organic matte (OM), total Nitrogen (N), available phosphorus (P) and exchangeable potassium (K) relative to soil and thereby, achieved the desired level for nourishing the supply of nutrients for plant growth and development as soil amendments. The higher percent OM of GC could probably partly retain longer within the soil and this might favor the residual materials to enhance further during the gradual release of available nutrients during mineralization and immobilization of microorganism through decomposition of OM [9].

Table 1. Initial soil and guano char analysis prior to crop establishment.

Elements	Medium soil Soil	Guano Char
pH (H_2O)	5.99	7.68
OM (%)	2.47	15.08
Total N (%)	0.15	6.93
Available P (mg/kg)	2.00	21.15
Exchangeable K (mg/kg)	0.43	61.43

Horticultural Morphological Characteristics of Lettuce

Foliage Growth and Development

Table 2. below shows the plant height and diameter, length and number of leaves were significantly influenced by the residual effect of GC at different rates of application as amendments for 15 kg soil. Plant height of lettuce showed that 600 grams levels of GC achieved the taller plants as compared to the other levels of guano application of T3, T4 and T5 as well as in the control and commercial nutrient solution. Meanwhile, the levels of 600 grams and 300 grams of GC have significantly wider diameter and length of leaves with more leaves develop relative to other levels of GC (T3 and T4) and to other treatments (T1 and T2).

However, the optimum level of GC which efficiently influenced the foliage production of lettuce was at 300 grams of GC though comparable with the 600 grams GC. This levels of application of GC had surpassed the effect of CNS to promote foliage lettuce production. The potential foliage outcome generated from 300 grams of GC could lowered the cost of production relative to 600 grams GC and thereby, improve the production margins of lettuce. The increased of lettuce foliage growth and development from 300 grams and 600 grams GC treatments could probably the influenced of better soil environment characteristics of the medium such as nutrient status, pH and cation exchange capacity (CEC) [10], [11], [12].

Table 2. Plant height and diameter, length and number of leaves 25 days after harvest.

Treatment	Plant height *(cm)*	Diameter of leaves *(cm)*	Length of leaves *(cm)*	No. of leaves
T_1- control	8.58 c	3.60 d	4.98 d	1.94 b
T_2- CNS	7.36 c	6.16 b	8.02 c	2.03 b
T_3-750 g GC residue	7.63 c	4.15 d	8.65 bc	3.34 b
T_4-150 g GC residue	7.59 c	5.74 bc	9.92 b	3.22 b
T_5-300 g GC residue	10.83 b	8.71 a	13.17 a	6.01 a
T_6-600 g GC residue	13.74 a	8.60 a	14.43 a	6.59 a

Means having the same letter in a column do not differ significantly at 5% level of significance using LSD.

Root Growth and Development

Table 3. shows the root volume, fresh weight (FW) and oven-dried weight (ODW) of root of lettuce was significantly influenced by the application of different levels of GC. But there was no significant difference obtained from the root length. The 600

grams of GC had more volume of roots from among the other treatments but are comparable to commercial nutrient solution and to the rest of GC levels of application except for 75 grams of GC (T3) and control (T1). However, the levels of 300 and 600 grams of GC had heavier root mass (FW and ODW) relative to the rest of other treatments. But the optimum level of GC was realized in 300 grams which could probably alter the foliage production of lettuce to increase, as what was observed in Table 2. This was in accordance to the biochar (BC) findings in lettuce as reported by Gu [13] that BC had higher fresh weight as compared to non-BC organic components.

The higher root mass obtained from 300 grams of GC could probably attributed by the good quality of foliage production (Table 2). This was reported by Prendergast-Miller et al. [14], Brennan et al. [15], and Keith et al. [16] that biochar components have significant effect on root biomass because char particles contact directly to plant roots. Thus, the findings of the study revealed that the influence of GC in lettuce rooting traits was associated more on the respond of biomass accumulation which was also emphasized by Eissenstat & Yani [17].

Table 3. Plant height and diameter, length and number of leaves 25 days after harvest.

Treatment	Root length *(cm)*	Volume of roots *(cm)*	FW of roots *(cm)*
T_1- control	6.04	0.89 b	1.06 d
T_2- CNS	9.17	1.24 ab	2.25 bc
T_3- 75 g GC residue	8.78	0.81 b	2.06 c
T_4- 150 g GC residue	8.13	1.52 ab	2.52 b
T_5- 300 g GC residue	7.02	1.49 ab	3.09 a
T_6- 600 g GC residue	6.05	1.92 a	3.27 a

Means having the same letter in a column do not differ significantly at 5% level of significance using LSD.

Yield

In Table 4. the yield of lettuce was significantly influenced by the residual effects of GC. The 600 grams of GC have achieved the highest yield from among other residues of GC as well as to the CNS and control, and this was followed by the 300 grams of GC. The highest yield obtained by 600 grams of CG might be the influenced of a good quality production of foliage and roots biomass generated during the growing period of lettuce 25 days after planting, as shown in Table 2 and 3. The yield of 300 and 600 grams of GC was within the range of 12 to 15 tons/ha as reported by PCARRD [18] and this value of yield exceeds the effectivity of CNS (inorganic). Therefore, the residue of 300- and 600-grams GC in a 15 kg soil was suitable for the growth and development of lettuce grown under pot. However, the recommended levels of GC from this study was at 300 level in which the cost incurred by the GC becomes doubled in a 600 grams levels that consequently might lowered the production margins of lettuce.

The higher yield influenced by biochar components was revealed by Upadhyyay *et al.* [19] that biochar at 30 ton/ha had significantly influenced the growth and yield of lettuce which is 10 tons/ha lower than what is recommended by the study at 300 grams of GC in a pot which is equivalent to 40 ton/ha when applied in the field. However, their experiments have directly implemented biochar component as an amendment in a soil but not as a residue from another crop (corn).

Table 4. Foliage yield of lettuce 25 days after planting

Treatment	Actual Yield *(g/plant)*	Computed Yield *(ton/ha)*
T_1- control	7.48 d	2.99 d
T_2- CNS	16.38 c	6.55 c
T_3- 75 g GC residue	12.87 cd	5.15 cd
T_4- 150 g GC residue	13.53 cd	5.41 cd
T_6- 300 g GC residue	34.83 b	13.93 b
T_6 - 600 g GC residue	44.14 a	17.65 a

Means having the same letter in a column do not differ significantly at 5% level of significance using LSD.

CONCLUSION AND RECOMMENDATION

Therefore, the used GC as a residue in lettuce had significantly improved the plant height; diameter, length and number of leaves; fresh and oven-dry weight of roots; and yield. The 300 grams of GC was the optimum levels that greatly influenced the growth and yield of lettuce. Hence, this study was performed in pot experiment, field trials is recommended to substantiate the significant effects obtained from this study in order to validate the consistency of the residual effects generated by GC.

REFERENCES

[1] USDA National Nutrient Data Base. Retrieved from: https://www.nutrition-and you.com/lettuce. html. Retrieved on January 22, 2018.

[2] Estero, O.P. (2007). Variety Evaluation of Romain Type Lettuce under La Trinidad, Benguet Condition. BS Thesis, Benguet State University, La Trinidad, Benguet. Pp. 1-5.

[3] Cabilovski, R., D.M. Bogdanovic, M.S. Manojlović and V. Rodic. (2011). Fertilization Economy in Organic Lettuce Production. Source:https://www.researchgate.net/publication/254371519_Fertilization_Economy_in_Organic_Lettuce_Production. Retrieved on January 22, 2018.

[4] Shetty, S, K.S. Sreepada, and R. Bhat. (2003). Effect of guano on the growth of Vigna radiate L. International Journal of Scientific and Research Publication. Vol. 3, Issue 3, ISSN 2250-3153.

[5] Slamet, W. (2017). Leaf are index, chlorophyll, photosynthesis rate of Lettuce (Lactuca sativa L.) under N-organic Fertilizer. Indian Journal for Agricultural Research (IJAR), Diponegoro University, Jalan Prof Sudharto SH, Tembalang, Semarang, Indonesia. Pp. 365-369.

[6] Charoenpakdee, S. (2014). Using animal manure to grow lettuce (Lactuca sativa L.) in a Homemade Hydroponics System. KKU Res. Journal. Pibulsongkram Rajabhat University, Phitsanulok, Thailand. Pp. 256-261. Retrieved from: Http://Www.Resjournal.Kku.Ac.Th/Abstract/19_6_34plus.Pdf.

[7] Chan K. Y, L. Van Zwieten, I. Meszaros, A. Downie, and S. Joseph. (2007). Agronomic values of green waste biochar as soil amendment. Australian Journal of Soil Research. 45, 629-634 doi: 10. 1071/SRO7109.

[8] Peasant, B. (2014). Your garden's soil pH matters. Ogden publications Inc. St. Topeka, Kansas. https://www.motherearthnews.com/organicgardening/gardening-techniques/soil-phzm0z14amzkin Retrieved on July 31, 2018.

[9] Duxbury, J.M., M.S. Smith, & J.W. Doran. (1989). Soil organic matter as a source and sink of plant nutrients. In D.C. Coleman, J.M. Oades & G. Uehara, eds. Dynamics of soil organic matter in tropical ecosystem, pp. 33-67. USA, University of Hawaii Press.

[10] Lehmann, J., M.C. Rillig, J. Thies. (2011) Biochar effects on soil biota – a review. Soil Biology & Biochemistry, 43, 1812–1836.

[11] Noguera, D., S. Barot, K. R. Laossi. (2012) Biochar but not earthworms enhance rice growth through increased protein turnover. Soil Biology & Biochemistry, 52, 13–20.

[12] Vanek, S.J., and J. Lehmann (2015) Phosphorus availability to beans via interactions between mycorrhizas and biochar. Plant and Soil, 395, 105–123.

[13] Gu, M. and F. Yu. (2012). Effect of biochar on yield of lettuce and basil in containers. ASHS Annual Conference. Retrieved from; ttps://www.researchgate.net/publication/267342311_Effect_of_Biochar_on_Yield_of_Lettuce_and_Basil_in_Containers. Accessed on: August 1, 2018.

[14] Prendergast-Miller, M., M. Duvall, and S. Sohi. (2014) Biochar-root interactions are mediated by biochar nutrient content and impacts on soil nutrient availability. European Journal of Soil Science, 65,173-185.

[15] Brennan, A., E.M. Jimenez, and M. Puschenreiter. (2014) Effects of biochar amendment on root traits and contaminant availability of maize plants in a copper and arsenic impacted soil. Plant and Soil, 379. 351-360.

[16] Keith A, B. Singh, F.A. Dijkstra (2015) Biochar reduces the rhizosphere priming effect on soil organic carbon. Soil Biology & Biochemistry, 88, 372–379.

[17] Eissenstat, D.M., and R.D. Yanai. (1997). The ecology of root lifespan. Advances in Ecological Research, 27, 1–60.

[18] PCARRD. (2015). Lettuce production guide with return of investment. Agri: Antrepinoys. Los Baños, Laguna. Retrieved from: http://www.mixph.com/lettuce-production-guide-with-return-of-investment-roi/

[19] Upadhyay, K., D. George, R. S. Swift and V. J. Galea. (2014). The influence of biochar on growth of lettuce and potato. Journal of Integrative Agriculture 13 (3):541-546. Retrieved from: https://www.researchgate.net/publication/260801581_The_Influence_of_Biochar_on_Growth_of_Lettuce_and_Potato. Accessed on August 1, 2018.

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