Effect of Biochar and Organic Fertilizer on Papaya Tree Quality

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Abstract

The purpose of this study was to see the effect of chicken manure and biochar on the fruit mass, abundance of fruits per tree, fruit length and width, and stem girth of papaya. The experimental design was a randomized complete block model with 60 plants in total and 15 per treatment. The four treatments included control, 1kg biochar, 1kg chicken manure, and 0.5kg biochar and 0.5kg chicken manure. Expected results are that the "combination of biochar and chicken manure" treatment will grant the highest quality trees followed by "purely chicken manure" then "purely biochar" followed by the control. Reasons for this include the variability of nutrients and organic material present in the combo treatment. Some studies have shown that biochar does not affect papaya yield which is why pure chicken manure may produce better tree quality, and the control treatment will likely produce the least yield due to a lack of supplements being added.

Introduction

Papaya is a commonly grown fruit being grown among people in the agriculture industry in Peru. Thus, it is important to understand what factors they're being supplemented that can help achieve the highest quality and quantity of product whilst causing minimal damage to the soil. This is especially important in the Neotropics considering that the soil is of such low fertility because leaf litter rarely stays on the soil due to a large variety of bacteria and fungus that decompose it.

A decomposing fruit or leaf would typically be bound to fungal threads that connect to tiny rootlets which recycle essential minerals such as phosphorus and potassium from the organic matter (Forsyth, 1984). To increase soil fertility, certain plants can be grown alongside papaya in a heterogeneous environment such that the increased leaf litter results in organic matter and humus (Stevenson, 1994). This can also help increase pest resistance due to increased variability of certain species which could increase competition or harm the pests (Cleveland, 1993).

One example is aphids that attack tomatoes. The defense response of the plant to one aphid can influence how strong its response is to another type according to Coppola et al. (2017). Although agriculture is ideal under such conditions, the purpose of this study is purely to test the supplements being used, so the plants will not be grown in a heterogeneous environment to not lead to confusion when assessing what factor is what lead to the increase in papaya quality.

The supplements that are of interest (excluding water) are biochar and chicken manure. Biochar is organic matter burned under conditions of minimal airflow that has been known for in traditional agricultural practices. As a result of high porosity, they are known to increase the cation exchange and water retention capacities of the soil (Li et al., 2017). The reason chemicals such as

synthetic fertilizers, herbicides, and pesticides are not of interest as a supplement is so that the soil does not get damaged over time and lose its fertility.

Soils with continuous applications of synthetic fertilizers deplete soil fertility according to Setyowati et al. (2017). Such chemical usage can lead to land unusable for agriculture which can lead to more forest that needs to be cleared for agricultural purposes. However, herbicides are an exception because manually clearing weeds is unfeasible and is likely to not be replicated by local farmers.

To minimize herbicide usage, some dead grass from a cleared field can be left to minimize weed growth. Also, the reason other manure types such as cow manure was not included is because chicken manure is more readily available and releases far less methane gas than cow manure. Chicken manure is especially ideal for papaya considering the slow release of nutrients it provides and the fast uptake of nutrients by this species. These supplements are used because of their sustainability and there are very few such studies specific to papaya.

With this study, we aim to analyse the effect of different organic treatments on papaya plants by monitoring their growth and yield. We hypothesize that plants receiving the mixture of biochar and chicken manure will benefit the most in terms of growth and fruit production.

Materials & Methods

Site Description

The experiment was conducted on the 54 hectare property of Finca las Piedras (S 12°13.570'; W 069°06.850') in the Madre de Dios region, Peru. The site is surrounded by high humidity tropical rainforests which can get colder despite the dry season as sometimes strong Antarctic winds called "friajes" can lower the temperature despite the location being relatively not too far from the equator. Some soils may be more silty than others as they are typically near moist areas near the "aguajal" (Mauritian palm swamps). The soil that the papaya seeds were planted on were compost-enriched and time of planting was August 13, 2019 (towards the end of the dry season).

Preparation of Seeds

To be consistent with Munoz et al. (2004), 12 individual papaya seeds per treatment were the approach for the bear minimum; however, this number was increased by 25% in the case sme papaya trees may not make it to the time of fruiting (leading to 15 papayas per treatment). Due to the possibility of seeds not germinating because of certain animal species that may have predated on them or the seeds not being dry enough at the time of planting (causing the sarcotesta to be attacked by fungi), double the number of 15 seeds and 3 seeds per bag was used as a precaution (30 per treatment and 3 seeds per bag for 4 treatments meaning 360 total at first). Papaya seeds were taken from a single fruit (in order to minimize differences in growth due to genetics) and left to dry for a few days in a shady area under a mesh with constant airflow. This excluded any possibility of mold growth on the seeds. Once dry, they were planted ~1cm deep in 175cm^2 (10x17.5cm) silicon bags filled with soil and watered daily (with the exception of rainy days) until they germinated and the

shoot appeared ~0.3m above the soil (which took around 61 days).

Supplement Preparation

Previously prepared biochar was obtained by burning organic matter which was left to dry. In this case, the organic matter burned was brazil nut shells. The dry mass was taken to get an indication of how much 1kg of biochar takes up volume to indicate how much is needed to be applied to the soil (22.5kg was needed). Chicken manure was also left to dry for the same reason. The biochar was then charged by using a solution of 33.8 grams of shorebird manure and 3.2 liters of water for every 1kg of biochar. After the solution application, it was left to dry and settle for a day. As mentioned earlier, these treatments were chosen because sustainable methods were the approach for this study.

Treatments

All treatments were watered daily with the exception of days with heavy rain. The treatments include: treatment 1 (this was the control treatment meaning no additional supplements were received other than water), treatment 2 (this treatment received 1kg of biochar per papaya tree as a 1 time application mixed in with 30cm deep x 30cm diameter of the soil during planting), treatment 3 (this treatment received 1kg of chicken manure per papaya on a monthly basis from the day of planting onwards), and treatment 4 (this treatment received both treatments 2 and 3 applications but only 0.5kg of the supplements instead of 1kg).

Experimental Design and Planting

To avoid biases as to which treatment goes to which row, an RCB (Randomized Complete Block) design was tested with 3 blocks of the four treatments in a randomized order. A random number generator was used for this. Other studies such as Munoz et al. (2004) and Santos et al. (2015) also used RCBs as well when addressing the effects of chicken manure and synthetic fertilizers on certain papaya variables. As a result, this was considered an appropriate design for this study. The papayas were planted in a cleared field by clearing a 3m buffer zone and burning the interior. However many survived in the bags, only 15 were used per treatment in order to not clear too much land so that the project is feasible and realistic. Per treatment, the papayas were spaced 2m apart as per Santos et al. (2015), 3m between the different treatments, and 3m away from the neighboring forest or grassland (to avoid other plants influencing the experiment) for a total area of $540m^2$ (36x15m) (Figure 1) where all plants receive the same amount of light and water as they are in an open field.

Data Collection, Analysis and Variables

By the time the papayas fruited and the first fruit was ~25%-50% ripe on each tree, the fruit was harvested and measurements were taken on fruit mass using a balance and length and width using a measuring tape, wrapping it around the papaya and getting the widest circumference by width and length. The abundance of fruits per tree was also a variable estimated by counting the number of fruits 1 month after time of fruiting. Stem girth was measured using a measuring tape 0.91m above ground

at the time of first fruiting (when about 6 months old). The treatments were compared to see if there were any significant differences between the treatment means for each variable using ANOVA. Among the significant differences, Tukey's test was used to test how they differ (which treatment has statistically significant differences from which treatment).

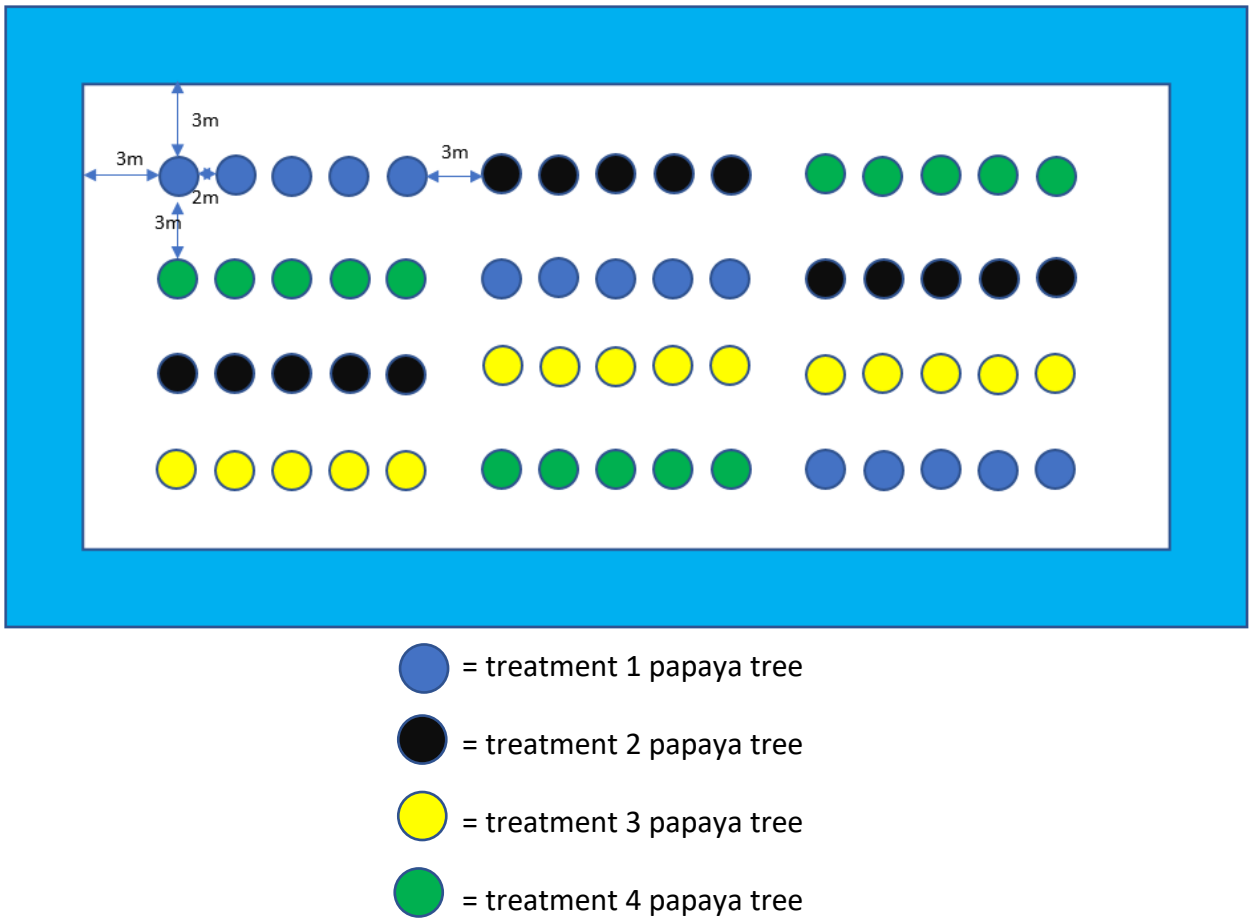

Figure 1: Figure illustrating experimental design (not to scale)

Expected Results

The control treatment is likely to give the least fruit yield and mass. This is because of the lack of nutrients being supplemented to the papayas. This is followed by treatment 2 because some past experiments have indicated that biochar does not affect papaya yield. Additionally, in the case of bananas, biochar can significantly decrease yield (Bass et al., 2016). Treatment 3 will then come afterwards due to how ideal chicken manure is for papayas as a fertilizer. Treatment 4 is predicted to result in the most yield due to the variability of the nutrients that it is likely to supplement and the variability of microorganisms that are likely to be present which could also, to some degree, make them

more pest resistant as well as provide the necessary nitrogen, phosphorous, and potassium needed.

References

Bass, A. M., Bird, M. I., Kay, G., & Muirhead, B. (2016). Soil properties, greenhouse gas emissions and crop yield under compost, biochar and co-composted biochar in two tropical agronomic systems. Science of The Total Environment, 550, 459-470. doi:10.1016/j.scitotenv.2016.01.143

Cleveland, D. A. (1993). Is Variety More than the Spice of Life? Diversity, Stability and Sustainable Agriculture. Culture & Agriculture, 13(45-46), 2-7. doi:10.1525/cuag.1993.13.45-46.2

Coppola, V., Soler, R., Rao, R., & Corrado, G. (2017). Tomato-mediated interactions between root herbivores and aphids: Insights into plant defence signalling. *Entomologia Experimentalis Et Applicata*, *163*(2), 170-176. doi:10.1111/eea.12572

Forsyth, A., Miyata, K., & Landry, S. (1995). Tropical nature. New York: A Touchstone Book.

Li, H., Dong, X., Silva, E. B., Oliveira, L. M., Chen, Y., & Ma, L. Q. (2017). Mechanisms of metal sorption by biochars: Biochar characteristics and modifications. Chemosphere, 178, 466-478. doi:10.1016/j.chemosphere.2017.03.072

Munoz, M. A., Rafols, N., & O'Hallorans, J. M. (2003). Yield and yield components of papaya grown on Coto clay (Typic Eutrustox) and fertilized with chicken manure. *Journal of Agriculture of the University of Puerto Rico*, *88*(3-4), 123-134

Santos, E. M., Cavalcante, Í H., Júnior, G. B., & Albano, F. G. (2015). Impact of nitrogen and potassium nutrition on papaya (Pawpaw) fruit quality. *Bioscience Journal*, *31*(5), 1341-1348. doi:10.14393/bj-v31n5a2015-26360

Setyowati, N., Muktamar, Z., & Puspitasari, I. (2017). Weed Based Organic Fertilizer to Reduce Application of Synthetic Fertilizer in Mustard (Brasiccasinensis L.). doi:10.31219/osf.io/t3aun

Stevenson, F. J. (1994). Humus chemistry: Genesis, composition, reactions. New York: Wiley.

