SCAP
SOCIEDADE DE CIÊNCIAS AGRÁRIAS DE PORTUGAL

Soil adequation with organo-mineral substrates designed from wastes for Blueberry

Adecuación del suelo con substratos organo-minerales diseñados a partir de residuos para el arándano

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https://doi.org/10.19084/rca.28422

ABSTRACT

Perú is the world greatest exporter of blueberry, crop that needs acid soil pH and high content of organic matter. The later is obtained from forest topsoil or peat (from north of Europe), unsustainable fact. This study shows a friendly environmental and sustainable alternative, organo-mineral substrates made by wastes ("Agrotec"). Four treatments [Control (C), Chicken manure (CM), Agrotec A (AA) and Agrotec B (AB)] were used for basal dressing, where 6 months age blueberry plants were planted. It was followed a completely randomize block experimental design monitoring either edaphic and plant physiology parameters for ~9 months. Soil results showed how CM supply a high —but punctual— dose of nutrients and organic matter. Contrarily, designed substrates Agrotec A and B released nutrients gradually because were previously stabilized, which triggered a slow mineralization within soil. Thus, soil parameters under CM application showed an unstable behaviour respect to AA and AB. Physiological results showed a fruit yield increase with AA a AB (100 and 44 %) compared to CM. Even though they are preliminary results in field conditions, It seems that designed substrates are efficient along the time and a sustainable alternative for blueberry soil adequation.

Keywords: Organo-mineral substrates, waste recovery, Peru´s coast soils, organic matter, Agrotec

RESUMEN

Perú es el mayor exportador mundial de arándano, el cual necesita suelos con pH ácido y altos contenidos de materia orgánica. Esta última se obtiene del horizonte superficial de los suelos forestales o de turberas (procedente del norte de Europa), lo cual es una práctica insostenible. Este estudio muestra alternativas sostenibles, los substratos órgano-minerales elaborados a base de residuos ("Agrotec"). Cuatro tratamientos [Control (C), Gallinaza (CM), Agrotec A (AA) y Agrotec B (AB)] fueron usados como abonado de fondo, donde plantas de arándano de 6 meses de edad fueron transplantadas. Se realizó un diseño experimental de bloques al azar monitoreando tanto los parámetros edáficos como fisiológicos durante ~9 meses. Los resultados del suelo mostraron como la gallinaza aportó una gran cantidad —pero puntual— de nutrientes y materia orgánica. Por el contrario, los substratos diseñados Agrotec A y B liberaron gradualmente los nutrientes debido a su precvio proceso de estabilización, lo cual permite una mineralización más lenta en el suelo. Los resultados fisiológicos mostraron un incremento en el rendimiento con AA y AB (100 y 44 %) comparado a la gallinaza. Aunque son resultados preliminares en campo, los substratos diseñados son eficientes a lo largo del tiempo y son una alternativas sostenibles para la adecuación del suelo para el arándano.

Palabras clave: Substratos órgano-minerales, valorización de residuos, suelos costeros de Perú, materia orgánica, Agrotec

INTRODUCTION

Agriculture plus food chain service accounts for 11.3 % of gross domestic product (GDP) of Perú (BID, 2021). This sectors is growing fast, reaching 7500 million USD in exportation in 2020, becoming Perú the highest exporter of blueberry, overcoming 1000 million USD and ~15000 has of blueberry crop (AGN, 2020).

Peru weather let to grow high productive varieties such as *Biloxi* (most extended in the country). However, majority of crop lands are at Peru´s coast, where soil properties are no adequate for this crop. Blueberry plants required acid soils (pH between 4.5–6), and high content of organic matter (15–20 g kg^{-1}). In this sense, it is needed a soil correction management to adequate them to blueberry crop.

Nowadays, farmers are cropping in big pots filled with organic matter (mix of husk and bark), buying top-soil from the mountains, transport peat from north of Europe or use manure to fulfil the organic matter requirements of blueberry crop. For instance, chicken manure is the most demanded one due to the high fertilization properties but its price is more expensive.

Therefore, the objective of Inproyen was to develop organo-mineral substrates from different wastes to fulfil blueberry organic matter and other soil parameters requirements.

MATERIAL AND METHODS

Experimental design

Study field occupied 975 m^2 disposed in four blocks with four treatments in each one (Figure 1). Each treatment contain seven plants of blueberry (*Vaccinium corymbosum* var. Biloxi).

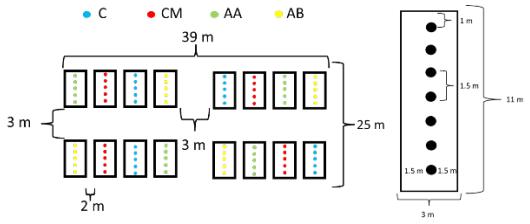

Figure 1 - Randomized block experimental design. C:Control; CM: chicken manure; AA & AB:Agrotec A & B.

Waste identification and characterization

Samples from 19 companies were taken to be physically and chemically analyzed. These companies are located in three different Peru´s departments (La Libertad, Lambayeque and Piura) surrounding the experimental area (Trujillo).

Design and implementation of substrats

It was made a theoric design of different proportions of wastes to synthesize two different organo-mineral substrates for blueberry. Once formulas were done, the next steps of the process were waste storing, mix and homogenization and maduration. Thus, it was get the two organo-mineral substrates, Agrotec 1 (AA) and Agrotec 2 (AB), that together with the Chicken manure (bought) and Control (no application) comprise the four treatments. All were analyzed phycallly and chemically (Table 1) before applying them in a trench —9 × 0.5 × 0.35 m— as base dressing with a rate of 40 tons per ha.

Table 1 - Physico-chemical properties of four treatments

ID	pH	EC	OM	N	P	K
Units		µS cm^{-1}			mg kg^{-1}	
C	8.8	146	1.3	404	981	852
CM	9.5	8090	284	8313	12900	15650
AA	7.2	5130	455	2100	3329	17060
AB	7.7	7973	435	3330	3963	15135

EC: electrical conductivity; OM: organic matter; N,P and K: Total nitrogen, phosphorus and potassium

Table 2 - Physico-chemical properties of four treatments

ID	pH	EC	OM	N	P	K
Units		µS cm^{-1}			mg kg^{-1}	
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Blueberry plants and irrigation

Blueberry plants were buying in a nursery and planting in each ridge, being watered with ~2.3 L/day/plant through the installed drip irrigation system.

Soil and plant monitoring

Soil parameters and plant physiology were analyzed during 9 months. It was done four soil samplings to analyze parameters such as pH, Electrical Conductivity (EC) , Organic matter (OM), Cation Exchange Capacity (CEC), avaible micronutrients, among others. Plant physiology samplings were done in leaves and fruits, analysing either number, size (23 samplings), as well as elemental composition (two samplings).

RESULTS

Soil evolution

Figure 2 shows pH evolution for four treatments. The decrease of pH was higher but irregular with

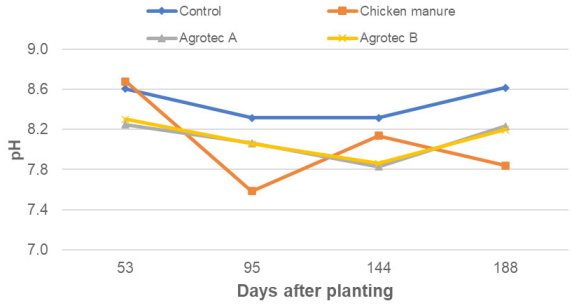

Figure 2 - Evolution of soil pH throughout edaphic monitoring

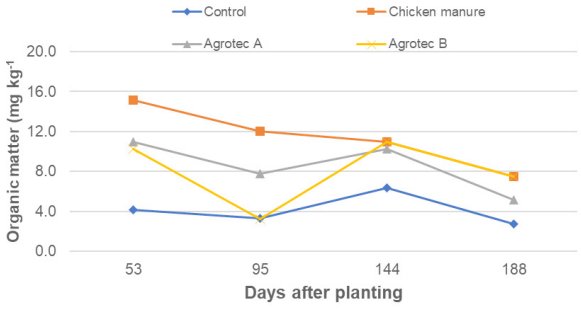

Figure 3 - Evolution of organic matter in soil throughout edaphic monitoring

CM treatment. The soil OM under different substrate treatments is very similar 188 days after planting (DAP) —Control excepted—, even though Chicken Manure treatment showed a big difference respect to others 53 DAP (Figure 3).

Total N in soil rapidly decreases in all treatments showing a rare increase 188 DAS discussed in next section (Figure 4).

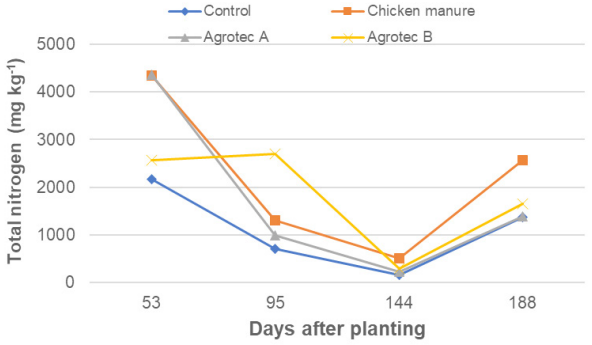

Figure 4 - Evolution of total nitrogen in soil throughout edaphic monitoring

The available phosphorus in soil (P Olsen) was very high with all treatments, highlighting the high strong decrease suffered by Chicken Manure treatment from 53 to 95 DAP (Figure 5).

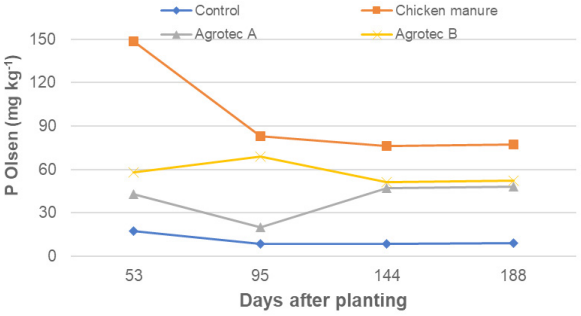

Figure 5 - Evolution of availability of phosphorus in soil throughout edaphic monitoring

One of the parameters that should be taking into account when manure is applied is the EC because it used to be high and can cause crop yield losses. Soil under CM treatment showed values of 1500 µS cm^{-1} 54 DAP that decreased to 900 µS cm^{-1} 188 DAP; whilst Agrotec A and B went from 600 to 500 µS cm^{-1} (Figure 6).

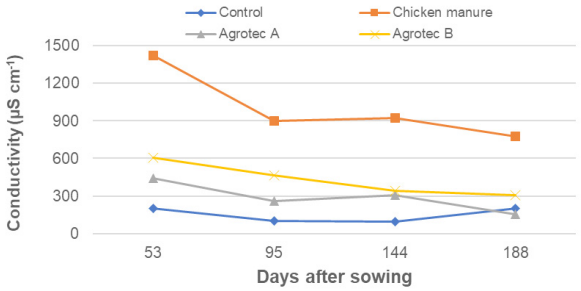

Figure 6 - Evolution of soil electrical conductivity throughout edaphic monitoring.

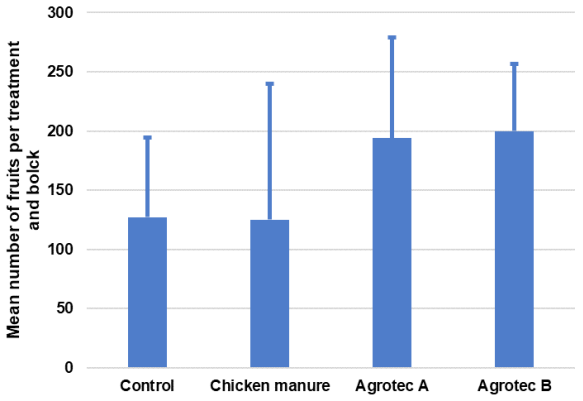

Figure 9 - Number of fruits produced by blueberry plants under different treatments

Crop performance

Blueberry was producing fruits during more than two months. These berries showed the highest size with Agrotec B and the lowest with Chicken manure (Figure 7). Even though plants were very small and the production was low, there were notable differences between treatments relative to blueberry yield (Figure 8). Agrotec B showed the best yield followed by Agrotec A, being 100 and 44% higher than CM treatment. This differences are related with the number of fruits produced wich followed same tren as yield (Figure 9).

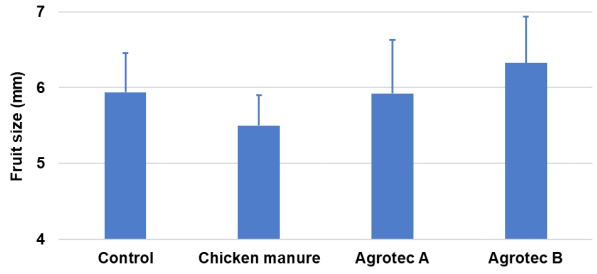

Figure 7 - Size of blueberry fruits (mm) under different treatments

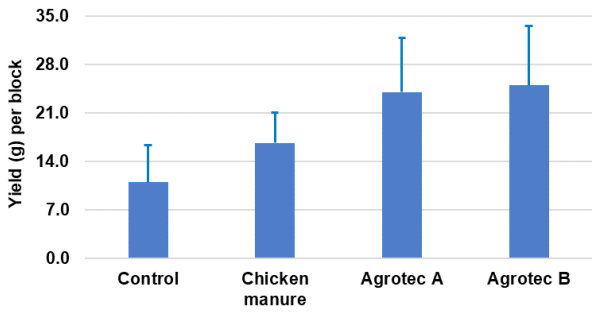

Figure 8 - Total yield (g) per treatment and block (seven plants).

DISCUSSION

Soil properties are seemingly better when chicken manure is applied, but this results did not correspond with the plant performance. The main explanation is the lack of stabilization of the Chicken manure substrate and its organic matter, mainly. This substrate quickly increases the soil OM content, as well as the amount of other nutrients, which cannot be absorbed by the plant as quick as they are delivered. However, Agrotec A and B, although did not fulfil pH value as expected, they showed a balanced behaviour along the experiment. This study can claim that "more is not always better" and a gradually nutrient delivery could be better for plant performance as it was shown here. Size of berries is one of the most valuable properties in blueberry crops. So, this parameter together with the increase in yield and number of fruits by Agrotec supports the need of a stabilization process of labil organic matter before applying into the field but also the use of more sustainable organic matter sources. Thus, waste recovery is a better alternative to adjust soil properties for blueberry crop due to decrease the waste produced, practice a circular economy and enhance soil properties and consequently the crop.

CONCLUSION

Create substrates from waste recovery for blueberry crop is possible. Besides, a correct design of Agrotec let fulfil the most important soil and plant

requirements and as it was shown with CM treatment "More, is not always better". Finally, it can be claimed that a stabilized substrate such as Agrotec A and B enhance the performance of blueberry crop, specially Agrotec B.

ACKNOWLEDGMENTS

This study was co-financed by PROInnovate Peru and Inproyen Consulting SAC, under agreement nº 597-INNOVATEPERU-PIEC1-2020, by the Ministry of Production (Peru).

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