

## Short-Term Effect of Alginate-Biochar Microbeads in Corn Germination

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**Abstract.** Biochar is the solid by-product of biomass pyrolysis. It is a promising soil conditioner and can be a material with high aggregate economic value, since its performance can improve plant's nutrient utilization and reduce the usage of conventional fertilizers. Biochar can be used in the formulation of new types of fertilizers as polymeric microbeads. These microbeads can be enriched with biochar and nutrients in its matrix to form fertilizers of slow release of nutrients. Thus, as a promising agricultural material, it is important to assess the environmental hazards caused by the implementation of these microbeads. In this context, seeds were sown in a soil-less Petri dish with microbeads produced with biochar from sugarcane enriched with or without phosphate. The seeds germination and its vitality were evaluated by the first germination count (FGC) and the germination speed index (GSI). The short-term effects showed that the microbeads, in general, assessed by the means of FGC, GSI and mass gain showed the best performance, suggesting that the environment created by these materials provided the best chemical and physical interaction with the embryonic axes.

**Keywords:** biochar, polymeric microbeads, short-term effects, seed germination

### 1. Introduction

Biochar has received attention from scientific community for its ability to work as a multifunctional material which can be used as a soil conditioner to enhance soil fertility, immobilize metals, increase soil drought resistance and, because of that, to recover the soil environment mainly due to its high water and nutrients retention capacity (and a proven cation exchange capacity) [1], [2]. In this context, biochar can be a material with high aggregate economic value, and could be used as a functional inclusion of a new type of fertilizer as polymeric microbeads.

Polymeric microbeads can be enriched with biochar and inorganic nutrients integrated into fertilizers of slow release of nutrients. Slow release fertilizers (SRF) may play an important role in improving fertilizer use efficiency by plants and may also reduce the frequency of fertilization, thereby mitigating environmental pollution. Coated fertilizers can be physically prepared from the granules of the soluble fertilizers by covering them with different materials [3], [4], which ensure a slow release of nutrients to soil by diffusion through the covering matrix or by erosion and degradation of the coatings [5].

Hence, the agronomical performance of these materials has to be investigated to demonstrate that the quality of the crop is enhanced. Thus, the aims of the present work were to examine the short-term effects of nutrients releasing polymeric microbeads, with and without biochar and phosphate enrichment on the germination index and to evaluate their agronomical quality.

### 2. Materials and Methods

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## 2.1. Pyrolysis - biochar fabrication

Sugarcane bagasse was used as the biomass waste material for the biochar fabrication. At first, the sugarcane bagasse was washed and dried at 80 °C for 24 hours. After this step, 30.0 g of the waste material were pyrolyzed in a muffle furnace using a horizontal cylindrical reactor of stainless-steel at 500 °C (SB500). The pyrolysis procedures were performed in a laboratory scale apparatus and were programmed to occur in two hours under oxygen-limited conditions introducing nitrogen gas at a flow rate of 0.5 Lpm and a heating rate of 10 °C min<sup>-1</sup>. Finally, the sample was grinded and passed through a 65 mesh sieve for the microbeads fabrication.

## 2.2. Microbeads fabrication

The microbeads were prepared with and without enrichment with SB500 and phosphate, and with the following controls: alginate microbeads (AB); phosphorous-alginate microbeads (PAB); biochar-alginate microbeads (BAB), and biochar-phosphorous-alginate microbeads (BPAB). For the microbeads with biochar, approximately 0.5 g of this material were added to a 100 mL solution of sodium alginate 2% (w/v) and homogenized for 1 hour. The pH of these parental solutions was adjusted to 4.0 and then homogenized for another hour. After this step, the solutions were dripped dropwise into a CaCl<sub>2</sub> solution (0.1 M) with the aid of a peristaltic pump. The speed of the peristaltic pump was controlled to maintain an optimal flow for the drops to not agglomerate. In addition, the porosity (ϵ) of the alginate coating was determined by using a gravimetric method, based on the differences in weight between the wet coating (surface drying with blotting paper) and dry coating (dried in 100 °C to a constant mass) [4] using the PAP and BAP microbeads to see the contribution of the biochar in these materials porosity.

## 2.3. Germination test

Ten corn seeds (*Zea mays*) were sown in Petri dishes on a layer of filter paper moistened with ultrapure water [6]. Six treatments were conducted, where the control was the seed sown in ultrapure water only. The other treatments were setup for: 0.5 g of biochar produced at 500 °C (SB500); 6.0 g of alginate microbeads (AB); 6.0 g of phosphorous- alginate microbeads (PAB); 6.0 g biochar- alginate microbeads (BAB), and 6.0 g of biochar-phosphorous-alginate microbeads (BPAB). All Petri dishes were covered with lids and incubated in the dark at 30 °C for 96 h. The tests were performed in duplicate. First germination count (FGC) was conducted with the germination test, by computing the percentage of normal seedlings on the fourth day after installation of the test. Finally, the rate of germination was checked every 24h, in order to calculate the germination speed index (GSI). The GSI was calculated by the Equation 1:

$$GSI = \left( \frac{G_1}{N_1} \right) + \left( \frac{G_2}{N_2} \right) + \left( \frac{G_3}{N_3} \right)$$

where  $G_1$ ,  $G_2$  and  $G_3$  were the number of plants computed in the first, second and final count and  $N_1$ ,  $N_2$  and  $N_3$  were the number of days of sowing associated to the first, second, and third counts.

## 3. Results and Discussion

During the evolution of the number of germinated seeds (Figure 1A), control and biochar powder (SB500) showed the lowest seedling performance. It indicates that the direct application of biochar into soil would not change significantly the seed germination. However, it is important to highlight that SB500 also shows no signs of toxicity to the seeds.

The systems that have higher rates of mass gain and IGS were the microbeads formed only with phosphate (PAB) (Figure 1B and 1D). The values found in these systems were of 164.0% of dry weight gain and 9.5 for IGS.

The first germination count (FGC) (Figure 1C) was taken as a baseline for determining the inhibition of germination possibly caused by the microbeads treatments. The control and SB500 treatments demonstrated lower rates than those presented by AB, BAB, PAB and BPAB.

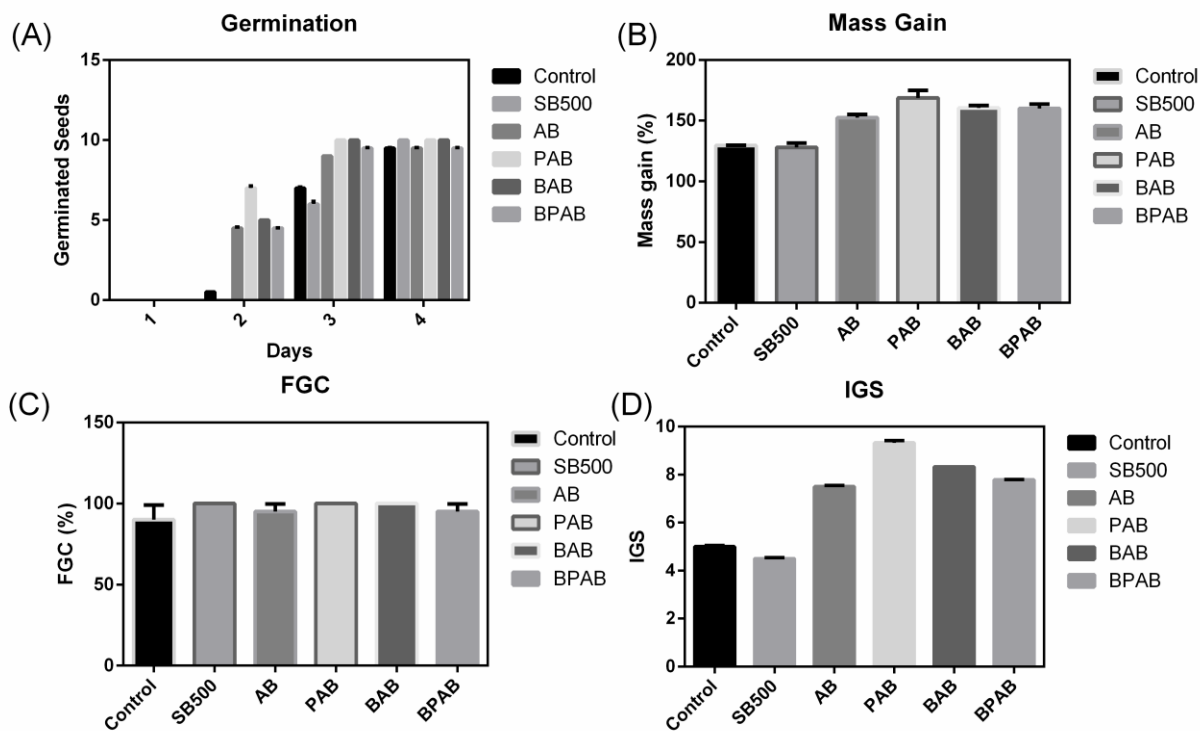


Fig. 1: Results in duplicate for the germination test was to evaluate the agronomic quality of the produced microbeads. (A) Evolution of germination according to the number of seeds germinated in 24h, 48h, 72h, and 96h; (B) Mass gain (dry basis) of the seeds; (C) First germination count, and (D) Index of germination speed for the established controls.

It was found that all the microbeads showed a maximum water content of 95%. The size of the microbeads ranged in diameter from 3.0 to 4.0 mm. At the end of the test, the microbeads lost weight, equivalent to a reduction of up to 50% in comparison with the initial weight. These data indicate that encapsulated fertilizers and soil conditioners can also work with a material that slowly releases water, favoring the maintenance of moisture and water retention in the systems used.

In addition, the porosity ( $\epsilon$ ) of the PAB and BAB, respectively, ranged between 57 and 68%. This indicates that microbeads enriched with biochar can be used as a dried material instead of those with no biochar, once the water penetrated easier into the first ones. The water content inside the beads dissolves the nutrient promoting its diffusion to the outside, hence leading to the nutrient release. This fact suggests that the presence of biochar in the microbeads affects the release of nutrients, perhaps due to the release of other ions from biochar surface and the increased concentration gradient of anions within the microbeads systems.

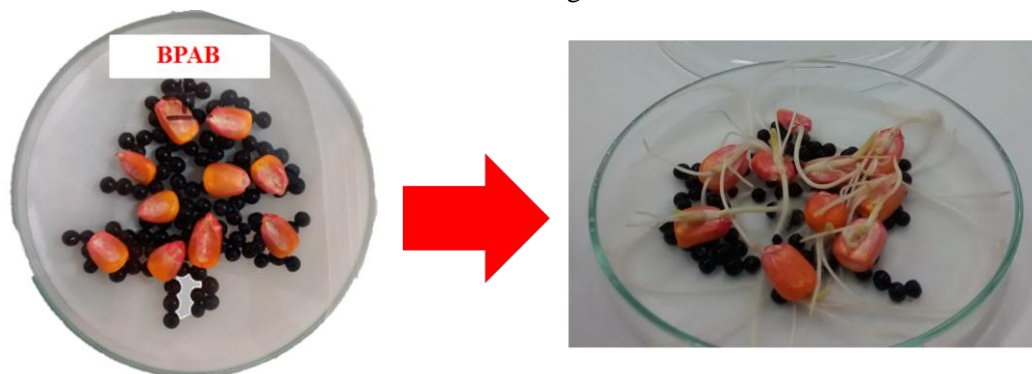


Fig. 2: BPAB microbeads treatment: at the beginning and at the end of the test.

The microbeads with biochar presented a black colour due to the biochar (Fig. 2). In the same figure can be seen all the seeds germinated and the microbeads still presented at the end of the test, which shows that

this material also works with slow release of water which influenced the moisture maintenance of the system. This characteristic was observed in all microbeads.

#### **4. Conclusion**

Since the aim of this work was to evaluate the agronomical quality of the polymeric microbeads, the germination test proved to be a reliable procedure to differentiate between the effects on seedling growth, when applying different types of microbeads. These preliminary tests showed that the microbeads, in general, had best performance, suggesting that the environment created by these materials provided the best chemical and physical interaction with the embryonic axes. The higher porosity observed in the SRB-B control suggest that this material could be used dried, and once wetted it would swell and release the inside nutrient. All microbeads remained wet throughout the entire assay, which suggest that an optimum and constant amount of moisture was provided for the system.

#### **5. Acknowledgements**

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