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Carbonized rice hull (CRH) silica extract efficiency for yield and nutrient uptake of cucumber

Andrea F. Dawan*, Gerald L. Seridon, Yvette D. Medrano

College of Agriculture, Cagayan State University, Piat Campus, Piat, Cagayan, Philippines

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Abstract

This study was conducted to determine the potential of agricultural waste such as carbonized rice hull (CRH) liquid extract as a source of silica and other nutrients for cucumber production. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three treatments and three replications. The treatments were 1) full recommended rate inorganic fertilizer (RRIF), 2) full RRIF plus RHA liquid extract and 3) half RRIF plus RHA liquid extract. Plots treated with liquid extract gave significant results compared with the RRIF alone, however, treatment 2 and 3 were comparable. This implies that application of half RRIF could meet the nutrient requirement of cucumber when applied with supplemental liquid extracts from carbonized rice hull. Further study on the effects of this liquid fertilizer for other crops is therefore recommended.

* **Corresponding Author:** Andrea F. Dawan ✉ afdawan@csu.edu.ph

Introduction

Cucumber *(Cucumis sativus* L.) is an economically important crop belonging to family cucurbitacaeae. It is also known to accumulate high levels of silicon (Si) in its shoots, for its uptake and Si xylem loading (Liang *et al.*, 2005). Moreover, the nutrient uptake rate by cucumbers is very high (Huang *et al.*, 2009), thus, tested for this study. Silicon is a useful element for organic plants growth (Ma and Takahashi, 2002).

In addition, plant growth and yield have also been improved by silicon application in plants such as cucumber. Moreover, it was found out that Si has no side effects to the environment when supplied to crops (Ahmed *et al.*, 2011).

The most debatable and studied element over decades contributing to the betterment of agricultural crops like cucumber is silicon (Si). The potentiality of silicon as an essential element has long been questioned, thus studied widely. On the other hand, rice hull is known to contain high silica and could be a complementary potential fertilizer source that is suitable for plant. The major compound of rice hull is silica and cellulose which yields carbon when thermally decomposed (Adylov *et al.*, 2003).

Furthermore, it is an agricultural waste product obtained from the milling of rice and it contributes to about 20% of the weight of rice (Koya *et al.*, 2013). Rice hull ash production contains nutrient materials which make it able to use as a fertilizer. This ash has almost 80% silicon (Franca *et al.*, 2017). Due to the overwhelming effects of silicon to plant growth and development, and the vast rice hull being produced in rice production, this study ought to prove that silicon and waste material such as rice hull can be used as a plant growth booster or fertilizer for cucumber.

The study generally aimed to determine the effects of the extracted silica from carbonized rice hull (CRH) on the growth and yield of cucumber.

Materials and methods

Soil characteristics, place and time of the study

The experiment was undertaken at the experimental field of Cagayan State University (CSU) Piat Campus, Piat, Cagayan, Philippines during the months of October to December 2018. The soil type is Bago sandy clay loam (Dagdag *et al.*, 1967). Based on the result of soil chemical analysis conducted prior to establishment of experimental trial, the soil has an acidic pH of 5.2, extremely low soil organic matter (SOM) content of 0.99%, relatively low available phosphorus (P) of 3.3ppm (Bray) and exchangeable potassium (K) of 51.7ppm.

The soil has SiO_2 content of 68.5%. This is relatively high as the type of the soil belongs to Bago series (*Vertic Argiudolls).*

Chemical composition of carbonized rice hull (CRH) liquid extract

The extract that was produced using combined acid pre-treatment and fermentation (Dawan *et al.*, 2020) was subjected to chemical analysis. The extract has a pH of 7.01, very low total N (0.22%), total P of 0.21%, total K of 0.33%, very low level of total Zn, Cu, Mn and Fe (0.02, 0.01, 0.01 and 0.06%, respectively). Moreover, silica content of this material is 7.33%. Total silica content optimum level should at least be 5% on standard percentage required by plants to attain its full yield potential (Fernandez *et al.*, 2013).

Experimental design, treatments and crop establishment

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments were 1) full recommended rate inorganic fertilizer (RRIF) (based on soil analysis), 2) full RRIF plus silica extract and 3) half RRIF plus silica extract.

The plot size was 5m x 5m (25m^2) with planting distance of 1m (between furrows) by 50cm between hills. Cucumber were pre-germinated in a polyethylene bag and transplanted in the prepared plots. Good agricultural practices (GAP) for cucumber were followed except for fertilizer application.

Parameters measured

Yield and yield component of cucumber

The average yield of the cucumber per plot was determined at harvest. Yield component parameter such as length of vine was also gathered.

Plant uptake

All the chemical analyses such as plant's total macronutrients (N, P, & K) and total micronutrients (Zn, Cu, Mn & Fe) were conducted at the ASL of DA-CVIAL, Tuguegarao City, Cagayan, except for the SiO_2 content analysis. Standard methods for chemical laboratory analyses were followed. Samples for silica content analysis were submitted to Chem Pro Laboratory in Pasig City following the standard protocol on sample preparation and submission.

These analyses were conducted to determine the nutrient absorption of crops especially of SiO_2.

Soil nutrient status at harvest

Soil characteristics such as pH, OM content, available P and exchangeable K were analyzed at ASL, DA-CVIAL to determine the effect of the applied liquid extracts on the soil. SiO_2 accumulated in the soil was also determined through ChemPro Laboratory.

Results and discussion

Cucumber yield and length of vine

Table 1 shows the effects of the treatments on the growth and yield of cucumber. No significant effect was noted in terms of length of vine measured at week 1, week 2 and at maturity, however longer vines were obtained from treatment 3 (half RRIF plus liquid extract) at week 1, week 2 and at maturity (40.2, 74.4 and 84.2cm, respectively).

The vine length determines the growth performance of cucumber and thus also determines the yield of the crop at maturity. This supports the yield of the cucumber as affected by the treatments. Highest significant yield was obtained in treatment 3 (half RRIF plus liquid extract) plots with a total yield of $7.92 t\cdot ha^{-1}$. Treatment 2 (full RRIF plus liquid extract) showed comparable results with treatment 3 with total yield of $7.15 t\cdot ha^{-1}$. Full RRIF plots obtained the lowest yield of $4.73 t\cdot ha^{-1}$.

Table 1. Yield ($t\ ha^{-1}$) and length of vine (cm) of cucumber as affected by the different treatments.

Treatment	Length of vine (cm)			Yield, $t\ ha^{-1}$
	Week 1	Week 2	At maturity	
Full RRIF	32.2	65.6	71.6	4.73 b
Full RRIF + Liquid Extract	32.6	68.5	72.0	7.15 a
Half RRIF + Liquid Extract	40.2	74.4	84.2	7.92 a

In a column for each property measured, means followed by the same letter are not significantly different at 5% level of significance.

Cucumber nutrient uptake

As shown in Table 2, no significant differences were observed in the plant total N, P, K, Zn, Cu, Mn and Fe uptake. This implies that increased amount of Si does not impede other nutrients to be taken up by the cucumber plant. The results are in contrary with the findings of Miyake and Takahashi (2012) in the case of water culture and field experiments wherein cucumber plants expressed severe leaf chlorosis without silicon. This condition happened in a solution where phosphorus (P) is high and zinc (Zn) is low. Their study also supports the results of this study where no direct effect was observed on the uptake or translocation of P or other nutrients to the shoot of the cucumber (Table 2). The results are very limited to the effects of CRH extract on the growth of cucumber and insufficient to classify Si as an essential mineral element for its growth and development. The mechanism by which level of Si present in the soil affects uptake of other nutrients will be considered in a separate study. It was also recorded that there were no known environmental side effects of Si supplementation to crops (Ahmed *et al.* 2011), thus further evaluation of this silica extract shall be done for validation and further enhancement to produce a readily available fertilizer material in the market.

Soil nutrient status after harvest

Table 3 shows the nutrient levels of the soil after harvest. These data also determine the uptake of nutrients by cucumber. No significant differences were obtained in terms of pH, available P and SiO_2. However, significant K level was recorded in plots treated with full RRIF plus liquid extract (233.3ppm). This is attributed to the higher K inorganic fertilizer applied in these plots. In terms of organic matter percentage, significantly higher value was obtained in plots treated with half RRIF plus liquid extract.

Compared with the initial soil nutrient status of pH (5.2), OM (0.99%), available P (3.3ppm), exchangeable K (51.7ppm) and SiO_2 (68.5%), slight improvement was noted in terms of available P and exchangeable K under full RRIF + LE plots. Significant improvement was noted in SOM and no differences in terms of pH and SiO_2 content. Increments observed were attributed to fertilizer applied in the plots that were not utilized by the crop in its growing period and might be available for the next cropping. It is then recommended to do the validation for at least two growing season to generate more reliable and stable results with regards to nutrient uptake.

Table 2. Cucumber nutrient uptake as influenced by the different treatments*.

Treatment	Plant nutrient uptake (%)							
	N	P	K	Zn	Cu	Mn	Fe	SiO_2
Full RRIF	3.03	0.12	2.50	37.00	13.67	215.0	872.7	91.3
Full RRIF + LE	2.77	0.12	2.25	35.33	13.33	242.0	860.0	92.3
Half RRIF + LE	2.60	0.10	2.83	32.33	13.67	223.3	725.0	92.0

In a column for each property measured, means followed by the same letter are not significantly different at 5% level of significance.

*ns – not significant

Table 3. Soil nutrient status at harvest of cucumber as affected by the different treatments.

Treatment	Soil chemical properties				
	pH	OM,%	P (ppm)	K (ppm)	SiO_2 (%)
Full RRIF	5.2 a	1.10 b	21.4 a	91.7 b	65.2 a
Full RRIF + LE	5.1 a	1.06 b	30.6 a	233.3 a	66.5 a
Half RRIF + LE	5.2 a	2.49 a	12.7 a	83.3 b	68.2 a

In a column for each property measured, means followed by the same letter are not significantly different at 5% level of significance.

Conclusion

Plots treated with liquid extract gave significant results compared with the recommended rate of inorganic fertilizer (RRIF) alone, however, treatment 2 (full RRIF plus liquid extract) and 3 (half RRIF plus liquid extract) were comparable. This implies that application of half RRIF could meet the nutrient requirement of cucumber when applied with supplemental liquid extracts from carbonized rice hull. Further study on the effects of this liquid fertilizer for other crops is recommended for future studies.

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