CUCUMBER BIOFORTIFICATION WITH POTASSIUM

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Abstract

A few years ago, humans consumed a diet rich in potassium, however, an increased consumption of processed foods and the reduction of the consumption of fruits and vegetables, has meant that potassium intake has been reduced. The aim of this study is to increase potassium content in cucumbers with natural biofortification of the crop, adding an extra amount of potassium sulphate ranging from 0.014 g/l to 4 g/l plus regular fertilization. Fourteen samples were collected at three different times that were analyzed with and without skin. The potassium content was determined by flame photometry. The results show that potassium content has increased over time and the differences initially existing between the cucumbers with and without skin have disappeared.

Keywords: Biofortification, cucumber, potassium

Introduction

Due to the majority of micro-nutrients are taken from vegetal products and their content in crops is not very high, in recent years biofortification is being investigated as a way of enriching vegetable products [1].

Biofortification of crops through the application of mineral fertilizers is used as an immediate strategy not only to increase the concentrations of minerals in edible crops, but also to improve yields in infertile soils [2]. Biofortification according to [3], consists of applying techniques that enhance nutritional or agronomic characteristics of the crop without becoming transgenic.

Potassium intake has decreased in recent years due to the reduction of fruit and vegetable consumption and the increase of processed food consumption [4].

In accordance with [5] hypokalemia, very frequent in hospitalized patients, carries an increased risk of heart, arterial, cerebrovascular and renal diseases. Some studies suggest a significant association between potassium intake and bone mineral density [6,7] . According to [8] during the exercise, the production of large quantities of sweat can cause electrolyte imbalances.

Our aim here is to increase potassium content in cucumbers with natural biofortification of the crop in a greenhouse, adding an extra amount of potassium sulphate plus regular fertilizer. We chose cucumber for the following reasons: it is one of the fruits with the highest content in potassium present in our diet, it is easy to use and to prepare, it has a great refreshing quality and a low calorie input, which is important for overweight or obese people with a high demand for this mineral. Furthermore, during the cooking of many vegetables there is a loss of micronutrients as indicated by [9], but in the case of the cucumber this problem doesn't exist.

Materials And Methods

Experimental zone

The greenhouse (**Figure 1**) is located in a natural setting in Punta Entinas-Sabinar between El Ejido and Roquetas de Mar (Almería). It has a drip irrigation system computerized, as well as temperature and humidity measurement stations which record these parameters through a computer program.

Cucumbers are Almería type come from seeds variety Valle (code 24-165Z) of the multinational RijkZwaan.

Figure 1. Greenhouse where the research took place.

Fourteen samples were collected from three different plants subjected to the same concentration of potassium sulphate used as a complement to the regular fertilizer as well as a control group with two samples, at three different times. The first collection of samples took place on 12th of December 2012, the second one on 25th of February 2013 and the last one on 3rd of April 2013.

The crop distribution is shown in **Figure 2**. The abreviation S1 corresponds to 0.014 g/l of potassium sulphate, S2 corresponds to 1 g/l, S3 are 2 g/l and finally S4 is equivalent to a concentration of 4 g/l.

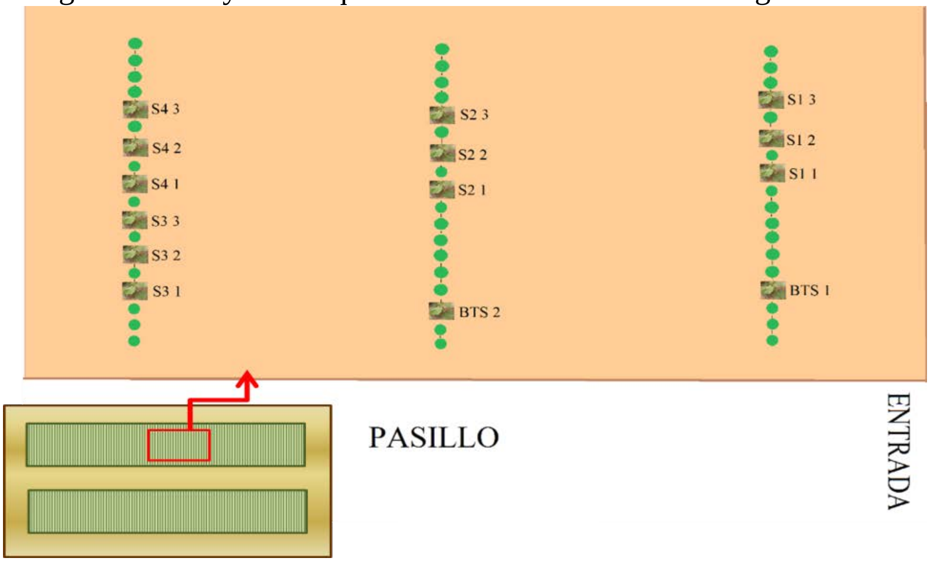


Figure 2. Samples distribution inside the greenhouse

Potassium sulphate was added through PVC bottles with a porous self-watering terminal (**figure 3**) situated next to the root of the plant (**figure 4**), which drop the potassium sulphate solution depending on the needs of soil moisture.

Figure 3. Bottles with dispenser

Figure 4. Bottles location

<u>Calibration of fruits</u>

According to [10] the size is an important variable from the commercial point of view, since it is used to classify products. For this purpose we have used a digital balance for the weight and a digital gauge to length and diameter.

Determination potassium content by flame photometry

Potassium content was determined by flame photometry, in accordance to the "Official methods of food analysis" [11].

- *Samples' preparation. Getting ashes*

In first place we prepared the samples by getting ashes from 5 g of cucumber with and without skin introduced in a melting plot, for this we slowly heated it in a sand bath and then we put the melting plot in the muffle furnace previously scheduled to 525ºC for 8 hours.

- *Curve pattern*

We made a calibration curve (**figure 5**) using potassium standard solutions to calculate the potassium content of the samples with the corresponding equation. For the elaboration of the curve pattern we use a potassium standard solution* of 1 g/L which was bought prepared, from this solution we prepared other ones of 0, 1, 2, 3, 5 and 7 mg/L. 0 Concentration mg/L is made only with water miliQ.

* Panreac Potassium Standard solution. K = 1, 000±0. 002 g/l ICP.

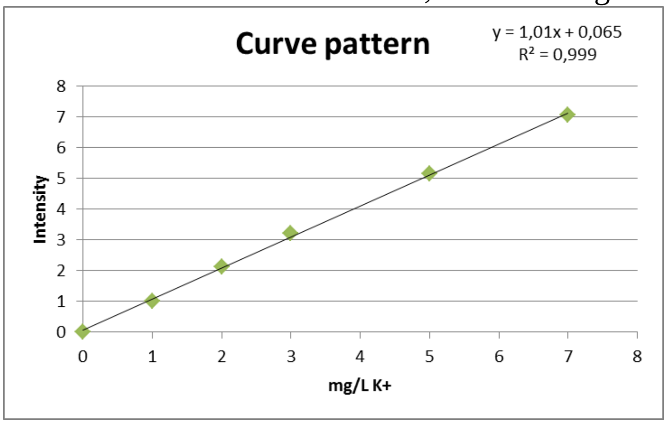


Figure 5. Example of curve pattern obtained in the study.

We measured the intensity of each sample three times with the flame photometer after making ashes filtration and appropriate dilutions to make the average of these results and obtain a more accurate result. The results are expressed in mg potassium/100 g cucumber.

Results And Discussion

In **table 1** we have set the maximum and minimum values, it shows a displacement of the maximum values over the time to the highest concentrations tested, whilst the minimum values remain in lower concentrations at the 3 different collected moments.

Table 1. Results potassium content in mg K + / 100g cucumber.

SAMPLES	1 st Collection	2 nd Collection	3 rd Collection
BTS 1 with	104,04	***76,00 m***	***102,69 m***
BTS 1 without	**92,9 M**	***70,68 m***	***98,24 m***
BTS 2 with	***95,86 m***	***85,05 m***	133,49
BTS 2 without	81,34	84,87	130,32
S1 1 with	106,2	***86,02 m***	***97,44 m***
S1 1 without	86,46	***81,85 m***	***90,24 m***
S1 2 with	***90,96 m***	89,37	123,02
S1 2 without	***65,03 m***	***80,85 m***	117,73
S1 3 with	**121,44 M**	96,42	139,08
S1 3 without	**99,76 M**	85,37	**131,44 M**
S2 1 with	**110,18 M**	**121,82 M**	***102,35 m***
S2 1 without	*73,98*	**115,29 M**	***93,64 m***
S2 2 with	97,36	98,62	104,44
S2 2 without	88,69	96,46	98,92
S2 3 with	*88,66*	**192,83 M**	131,58
S2 3 without	***68,33 m***	**181,96 M**	110,75
S3 1 with	**111,63 M**	87,08	**157,98 M**
S3 1 without	**93,65 M**	82,71	**143,4 M**
S3 2 with	106,8	95,7	140,68
S3 2 without	87,78	88,82	113,92
S3 3 with	101,44	**128,55 M**	122,32
S3 3 without	80,08	101,48	121,49
S4 1 with	93,21	117,57	133,48
S4 1 without	83,93	**110,95 M**	127,57
S4 2 with	102,32	107,6	**143,77 M**
S4 2 without	87,28	95,62	**138,69 M**
S4 3 with	100,67	106,15	**149,48 M**
S4 3 without	83,79	94,35	111,55

M: Maximum ***m***: minimum

Statistical analysis

Samples were characterized statistically according to their average, maximum and minimum values.

We used Friedman test for related samples (given the small number of samples we used non-parametric statistics) in order to check if there are significant differences over time with regard to the potassium content caught by cucumbers from the different concentrations supplemented and we see that this is so with 99% probability. We can affirm that there were significant differences consisting of a progressive increment of potassium content over time as shown in **table 2**.

Table 2. Averages for the content in potassium over time.

	Average
T1	92,9013
T2	105,9767
T3	122,7067

[12] indicate that the concentration of potassium decreases during cultivation in the greenhouse, however, we have achieved plant

biofortification so that there are statistically significant increases in the latter stages of the crop.

We have also applied Student's t- test to see if there are significant differences between the cucumbers analyzed with and without skin with a 95% probability. In the first collection, we found differences consisting on a higher potassium concentration in the case of cucumbers with skin, however, in the second and third collection there are no significant differences.

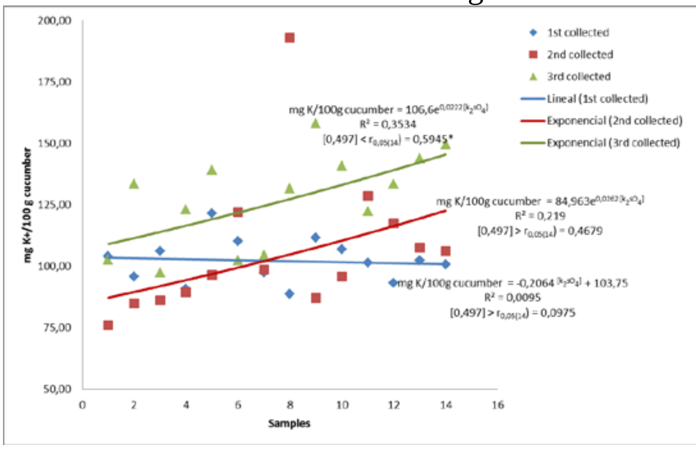
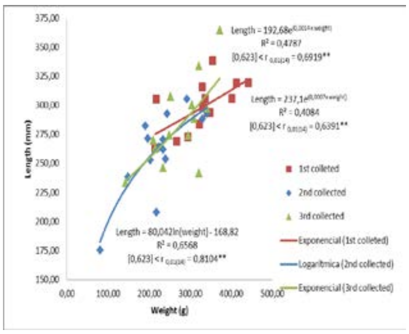


Figure 6. Correlation equations (potassium content) for cucumber samples with skin.

In **Figure 6**, we can see in the case of the first treatment there is no correlation. The second treatment seems an exponential trend. When we focus on the third treatment, we observed a shift of the curve that represents an exponential behavior with regard to the second collection, this new curve is parallel to the previous, producing a significant increase and with a good correlation coefficient, r = 0.5941 *, so we can use this equation to predict the final content of potassium in cucumber in accordance with the concentration which the same was supplemented. In the case of the cucumber samples without skin there is no reliable equation that can predict the behavior of potassium content.

We also studied the correlation between weight and length, weight and diameter.



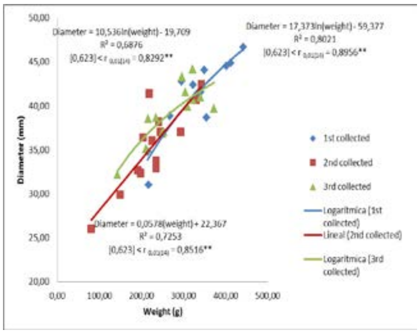


Figure 7. Correlation equations to length-weight. **Figure 8.** Correlation equations to diameter-weight.

In **Figure 7** the first and third collection are adapted to an exponential behavior and the other one into a logarithmic, all of them with a high correlation coefficient, so they can be predicted by one variable from the other one with a 1% error (□ = 0.01). When we relate diameter with weight (**Figure 8**) is found to have a sufficiently high correlation coefficient to consider them reliable in predicting one variable from another one with the same level of significance.

Conclusion

Potassium content has increased over time and the differences initially existing (first collected) between the cucumbers with and without skin have disappeared.

The potassium content of cucumber in accordance with potassium sulfate concentration used after the first two periods of crop (60 days) can be predicted

A relation between weight and potassium content was not detected.

There are reliable correlation equations to predict the length and diameter from the weight with a very small margin of error (1%).

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