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Chitosan improves growth and bulb yield of pineapple lily (*Eucomis bicolor* Baker) an ornamental and medicinal plant

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ABSTRACT

The wide demand for natural biostimulants encourages the search for new, alternative sources of substances with high biological activity. Chitosan can promote plant growth and root system development, enhance photosynthetic activity, increase nutrient and metabolite content. *Eucomis bicolor*, commonly known as the 'pineapple lily', is not widely known in terms of cultivation and biological activity. The aim of the experiment was to determine the effect of chitosan on growth of *Eucomis bicolor*. To the best of our knowledge, this is the first study to describe the effect of chitosan on morphological features of *Eucomis bicolor*. The results showed that soaking *Eucomis bicolor* bulbs in a chitosan solution before planting has stimulated the growth, flowering and yield of bulbs. Treating the plants with chitosan at 50 mg/L had the most beneficial effect on the number of leaves per plant, the relative chlorophyll content in the leaves as well as the number of bulbs per plant. Chitosan has a multi-directional, positive effect on plant growth and can be used as a potential biostimulant.

***Keywords*:** biostimulants, *Eucomis bicolor*, geophytes, ornamental crops, polysaccharides

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1. INTRODUCTION

Nowadays, there has been renewed interest in medicinal raw materials of plant origin [1-3]. The genus *Eucomis*, commonly known as the 'pineapple lily', containing 10-15 endemic species found in South African countries, is still little known and very attractive [4]. Plants have original inflorescences composed of small, star-shaped white, cream, white-green, yellow-green, pink or purple flowers ending with a characteristic rosette of small leaves. After flowering, the plants set decorative and durable green or purple fruits – capsules [5]. *Eucomis* species and cultivars are grown in the garden in flower-beds and for cut flowers. Species have the great potential to be used as potted plants for decorating interiors, balconies, and terraces. In South Africa, *Eucomis* species have long been among the most important medicinal plants and they exert multidirectional effects, among others, antioxidant, anti-inflammatory, bactericidal, and fungicidal effects [4,7]. *Eucomis* species are in danger of being extinct in the natural environment due to the excessive collection of bulbs for medicinal purposes, which is why efficient methods of plant reproduction are sought for and attention is drawn to the use of various compounds that stimulate their growth and development [8-10].

Currently, biostimulants consisting in a variety of substances and microorganisms that are used to increase plant growth and improve the quality of their yield are of great interest in agriculture and horticulture [11]. The wide demand for natural biostimulants encourages the search for new, alternative sources of substances with high biological activity. Natural polysaccharides are compounds exhibiting multi-directional action in plants; they are also biodegradable, biocompatible, non-toxic, reactively bioactive and inexpensive [12-13]. Particular attention is paid to depolymerized polysaccharides, which are characterized by higher biological effectiveness compared to the products from which they were obtained. Chitosan is an example of a popular polysaccharide with biostimulatory properties obtained on an industrial scale in the process of chitin de-N-acetylation [14-17].

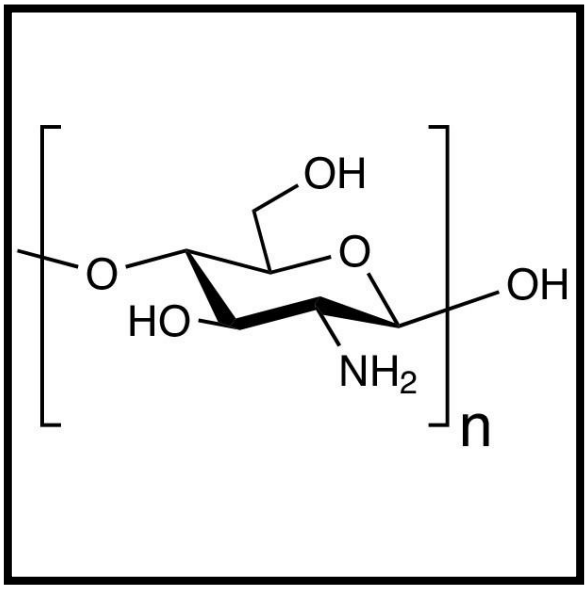

Figure 1. Structure of chitosan

Chitosan affects the growth and development of plants, regulates physiological and metabolic processes [18-23]. It has also been demonstrated that chitosan induces plant tolerance against several abiotic stresses, including salinity and drought exposure [24-30]. In practice, chitosan is applied in the form of a solution for spraying and watering of plants, as well as in the form of hydrogels for coating the seeds or corms [31-37].

Taking into consideration, the importance of chitosan as a plant biostimulant and the medicinal and ornamental value of *Eucomis bicolor*, the aim of the present experiment was to determine the effect of chitosan on growth, flowering and bulb yield of *Eucomis bicolor* in term of morphological features.

2. MATERIALS AND METHODS

The study was conducted in a heated greenhouse (22ºC/18ºC day/night; RH 80–90%) that belongs to the Department of Horticulture, West Pomerania University of Technology in Szczecin (53°25' N,14°32' E). The bulbs of *Eucomis bicolor* with a circumference of 16-18 cm were obtained from Holland.

Figure 2. The appearance of *Eucomis bicolor* inflorescence

Bulbs were soaked for 30 minutes in chitosan solution at concentration 50 or 100 mg/L. Bulbs soaked in water were the control. After treatment the bulbs were planted in plastic pots in mid-April. The growing medium used was a substrate of pH 6.5 that contained Hydrocomplex 5% N-NO_3, 7% N-NH_4, 11% P_2O_5, 18% K_2O, 2.7% MgO, 8% S, 0.015% B, 0.2% Fe, 0.02% Mn, and 0.02% Zn) with 3 g/L. At full blossom of the plants, the following parameters were defined:

- the number of leaves per plant
- leaf length
- leaf width
- the relative chlorophyll content in the leaves using the Chlorophyll Meter SPAD 505 (Minolta, Japan)
- the number of days to anthesis
- the number of inflorescences per plant
- inflorescence length
- inflorescence width
- the number of bulbs per plant
- total weight of bulbs per plant

The experiment was conducted as a single factor in a completely randomized design, in four repetitions, 10 plants in each. The results of measurements were statistically verified using a variance analysis model (ANOVA). Statistical product and service solutions software STATISTICA 13.0 package (StatSoft) was used for calculations. The differences between the groups were established by Tukey's test multiple comparison.

3. RESUALTS AND DISCUSSION

Statistical analysis of the results showed that chitosan treatment had strong promotive effects on all growth parameters studied except for inflorescence width and the number of inflorescences per plant (Figures 1-12). Application of chitosan improved leaf length, leaf width, SPAD, inflorescence length, inflorescence width, the number of bulbs and total weight of bulbs per plant. Furthermore, the plants soaked in chitosan began flowering earlier than the control ones (Figures 3-7, 10-12).

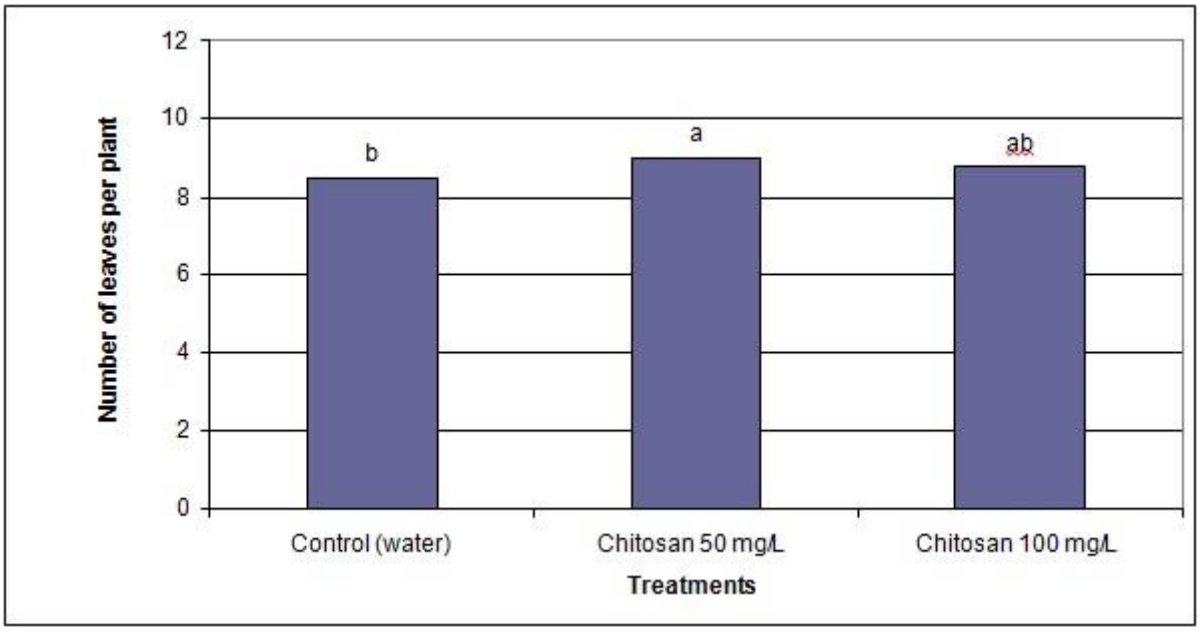

Figure 3. Effects of the concentration of chitosan on the number of leaves per plant of *Eucomis bicolor*. Means represented by columns marked with the same letter do not differ significantly at $p \leq 0.05$.

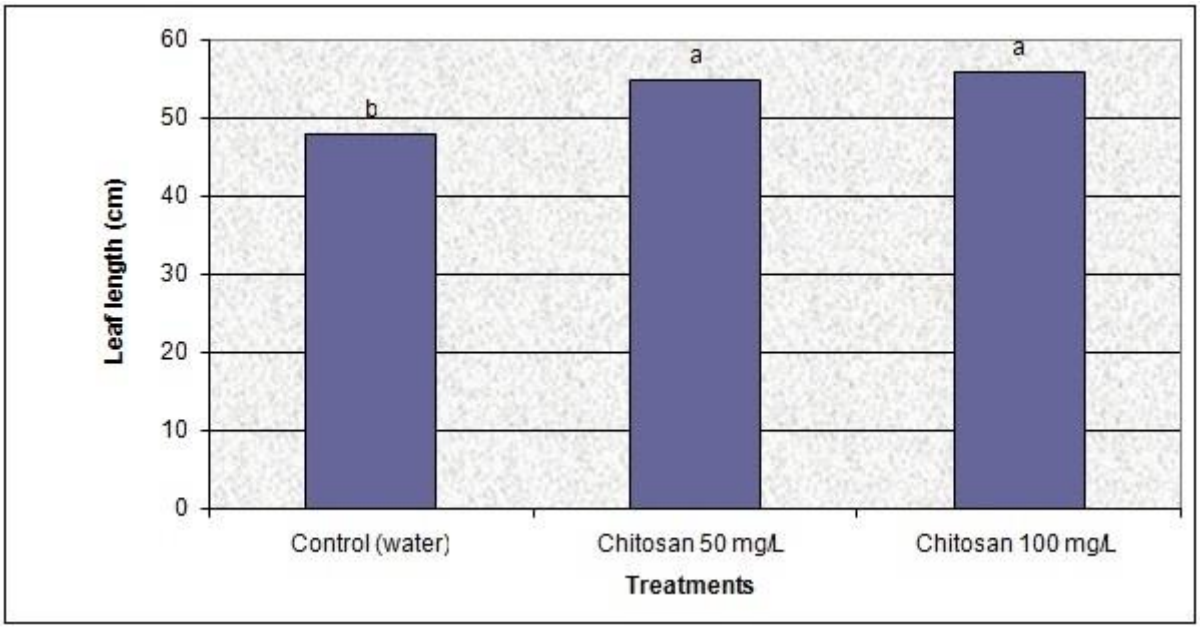

Figure 4. Effects of the concentration of chitosan on leaf length of *Eucomis bicolor*. Means represented by columns marked with the same letter do not differ significantly at $p \leq 0.05$.

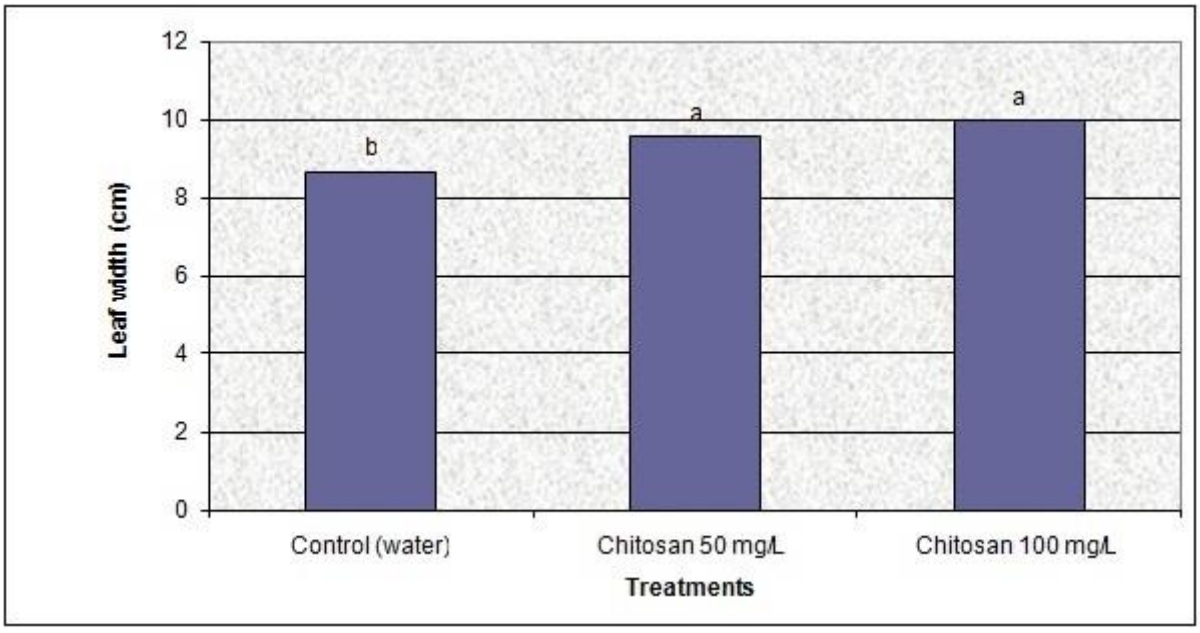

Figure 5. Effects of the concentration of chitosan number on leaf width of *Eucomis bicolor*. Means represented by columns marked with the same letter do not differ significantly at $p \leq 0.05$.

Treating the plants with chitosan at 50 mg/L had the most beneficial effect on the number of leaves per plant, the relative chlorophyll content in the leaves as well as the number of bulbs per plant. A similar positive influence of chitosan on plant growth was observed in several ornamental crops. The research by Salachna and Zawadzińska [8] showed that oligochitosan positively affected the growth of *Eucomis autumnalis*. The authors compared the growth, flowering and mineral content in *Eucomis autumnalis* plants obtained from bulbs coated in oligochitosan + sodium alginate 1%, treated with Kaptan + Topsin and non-treated plants. The obtained results proved that plants obtained from bulbs coated in biopolymers were the highest, had the longest leaves and produced the most flowers per inflorescence; moreover, they were characterized by the highest fresh mass of aerial parts and bulbs after harvest in relation to plants obtained from fungicide-treated and control bulbs [8]. In another study, Salachna et al. [38] studied the use of coatings containing oligochitosan and other ionic biopolymers in the cultivation of *Ornithogalum saundersiae*. The obtained results indicated the stimulating effect of all the tested coatings on plant height, the number of flowers in the inflorescence, the length of inflorescence shoots, leaf content of total chlorophyll, total polyphenols as well as nitrogen, potassium, phosphorus, boron and iron. The authors found that plants obtained from bulbs treated with oligochitosan and gellan gum began flowering first, had the longest inflorescence shoots and the most flowers in the inflorescence as well as were characterized by the highest bulb yield, the highest antioxidant activity and the highest contents of chlorophyll *a*, chlorophyll *b*, carotenoids, total polyphenols, L-ascorbic acid, phosphorus, potassium, zinc and manganese in leaves. Furthermore, in the cultivation of *Ornithogalum saundersiae* oligochitosan with a molecular weight of 100,000 g mol^{-1} increased the length and size of inflorescences and the weight of bulblets [37].

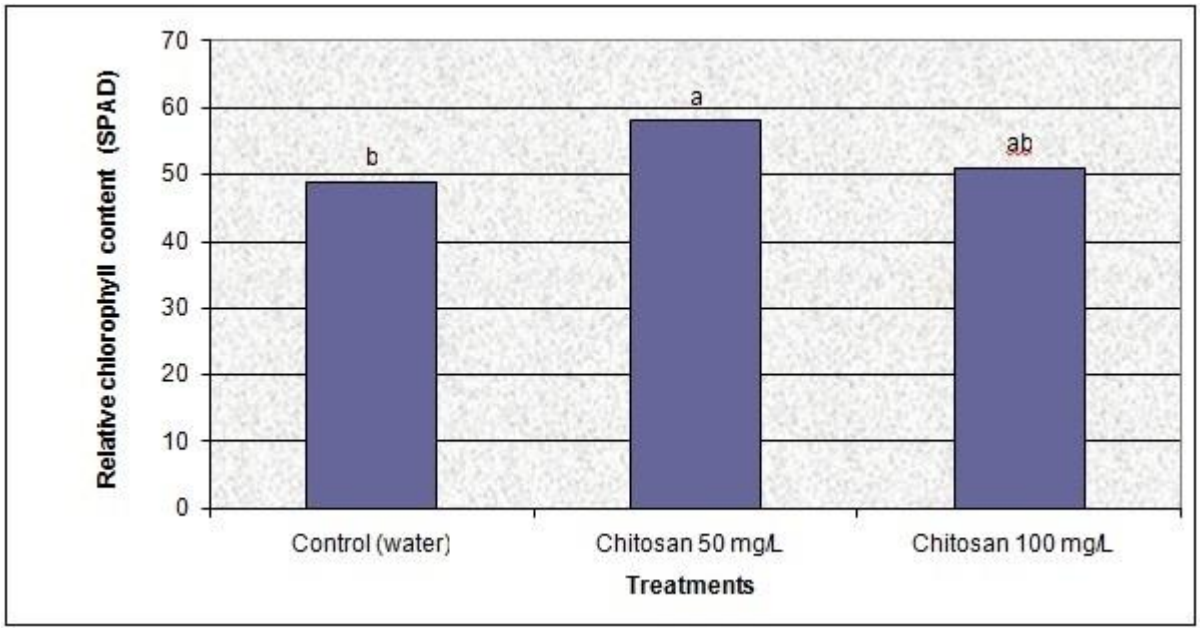

Figure 6. Effects of the concentration of chitosan number on the relative chlorophyll content (SPAD) of *Eucomis bicolor*. Means represented by columns marked with the same letter do not differ significantly at $p \leq 0.05$.

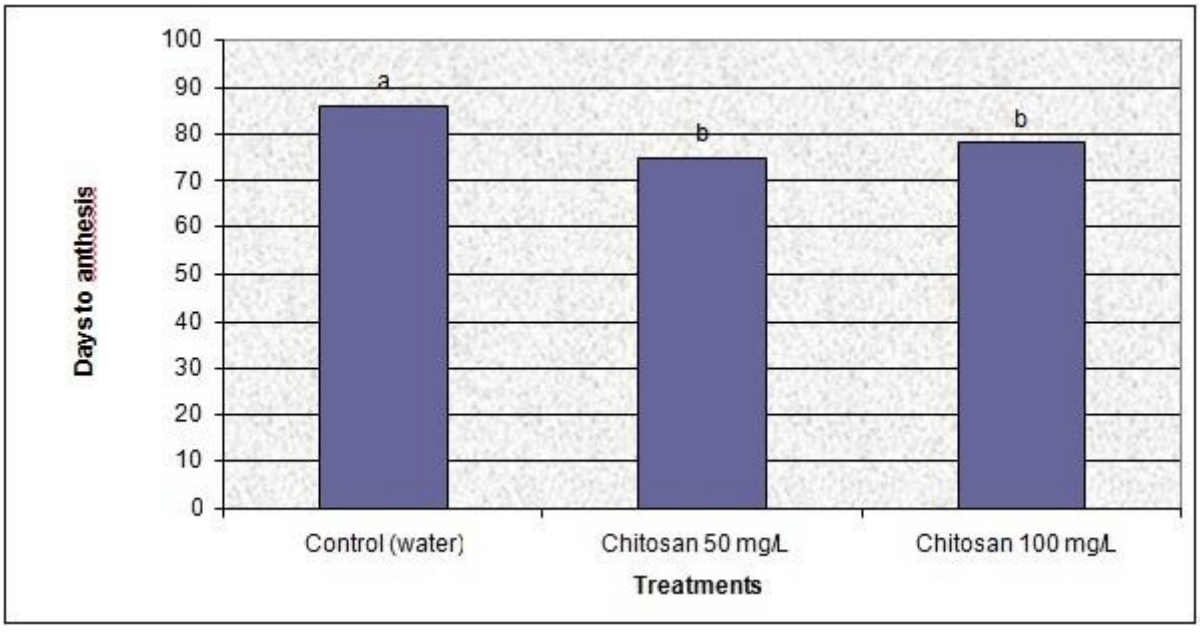

Figure 7. Effects of the concentration of chitosan on days to anthesis number of leaves per plant of *Eucomis bicolor*. Means represented by columns marked with the same letter do not differ significantly at $p \leq 0.05$.

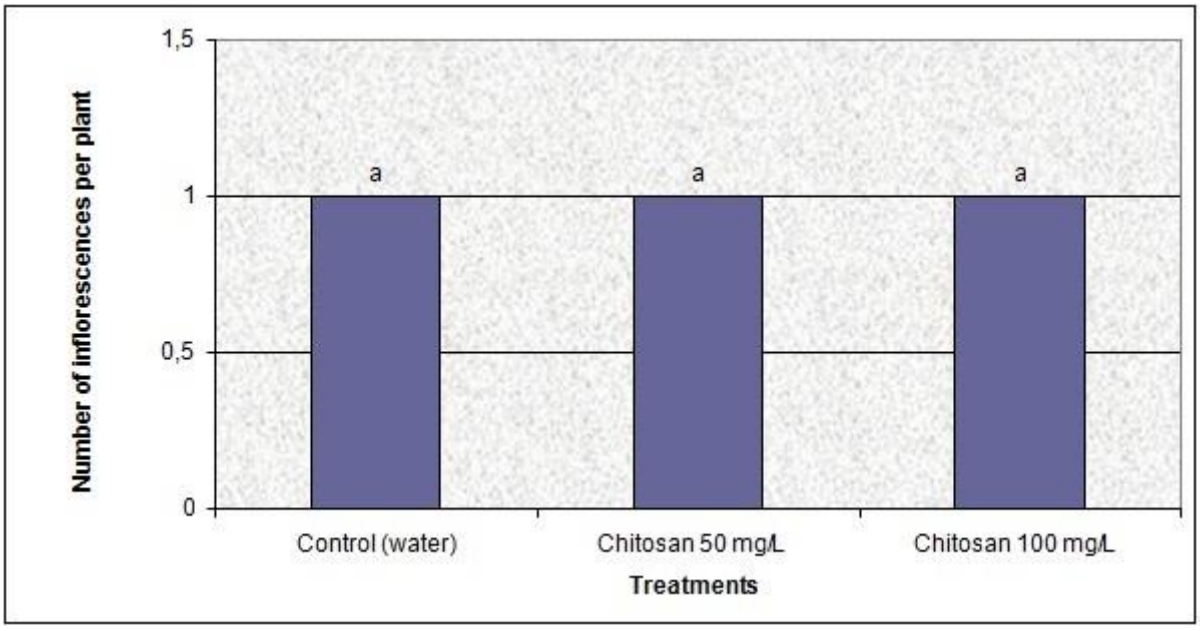

Figure 8. Effects of the concentration of chitosan on number of inflorescences per plant of *Eucomis bicolor*. Means represented by columns marked with the sameletter do not differ significantly at $p \leq 0.05$.

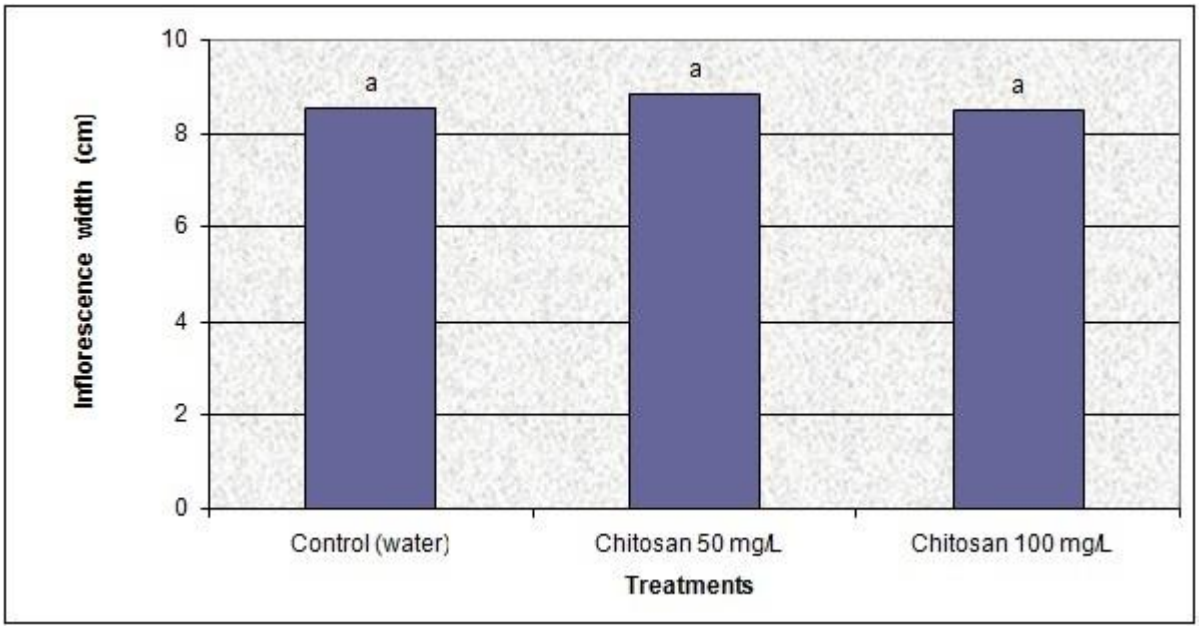

Figure 9. Effects of the concentration of chitosan on inflorescence width of *Eucomis bicolor*. Means represented by columns marked with the same letter do not differ significantly at $p \leq 0.05$.

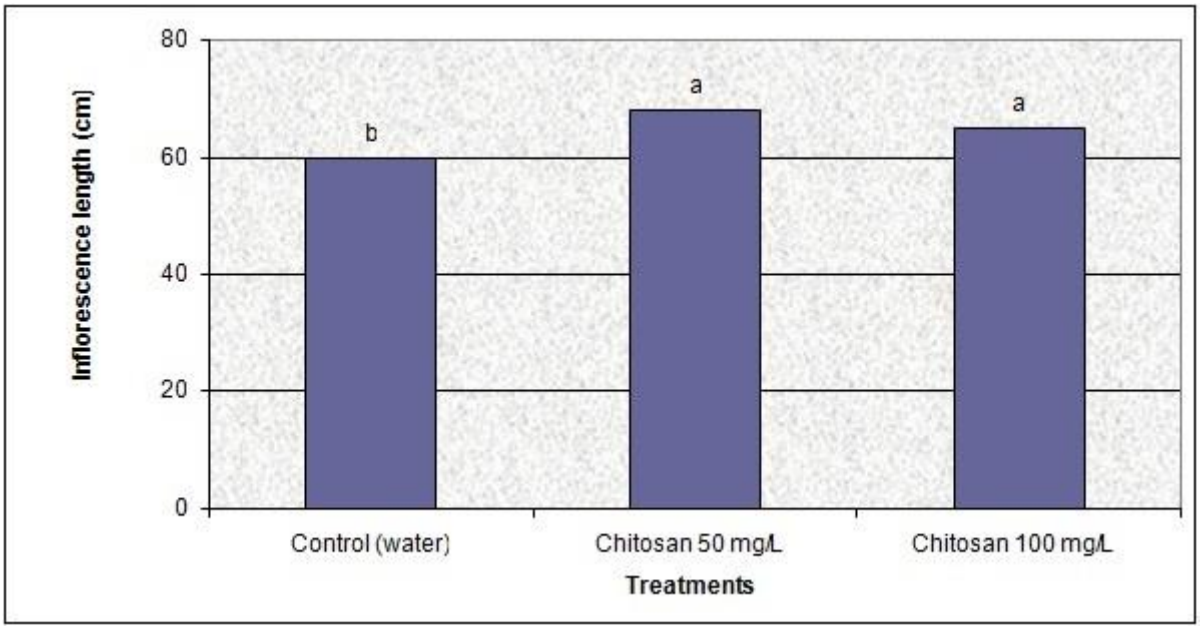

Figure 10. Effects of the concentration of chitosan on inflorescence length of *Eucomis bicolor*. Means represented by columns marked with the same letter do not differ significantly at $p \leq 0.05$.

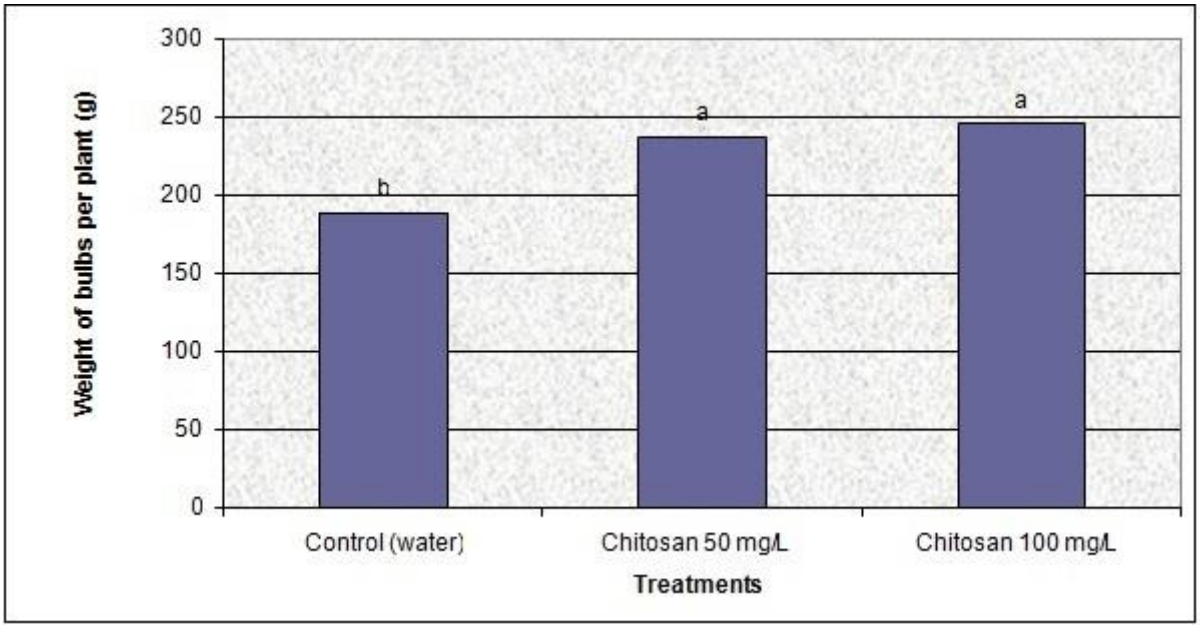

Figure 11. Effects of the concentration of chitosan on weight of bulbs per plant of *Eucomis bicolor*. Means represented by columns marked with the sameletter do not differ significantly at $p \leq 0.05$.

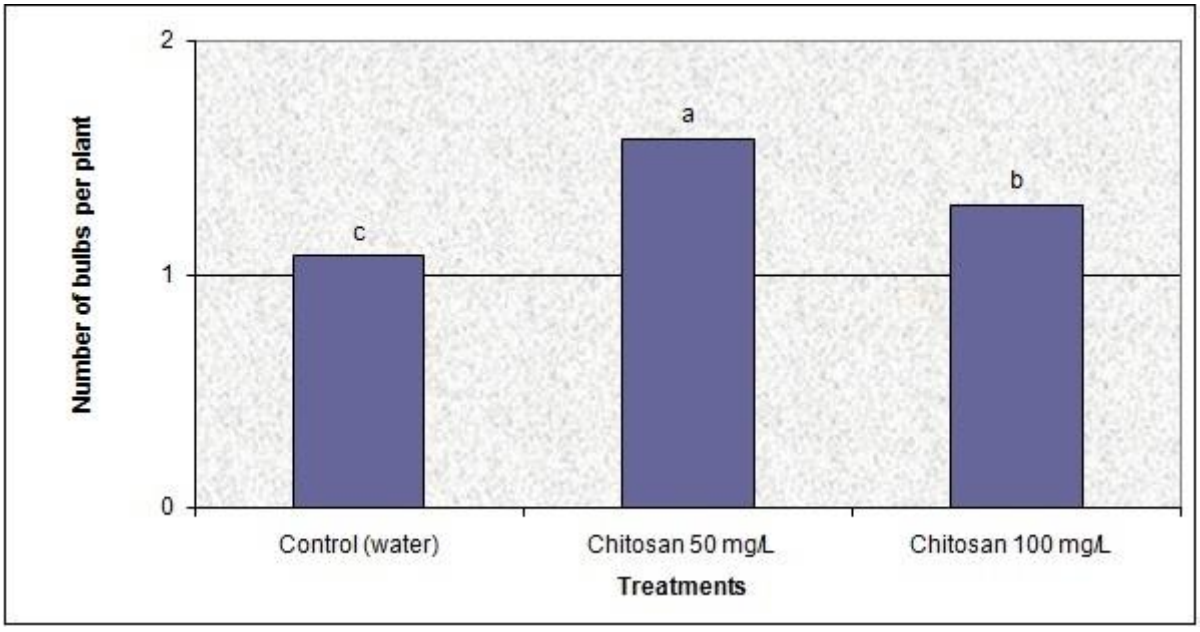

Figure 12. Effects of the concentration of chitosan on number of bulbs per plant of *Eucomis bicolor*. Means represented by columns marked with the sameletter do not differ significantly at $p \leq 0.05$.

It is interesting to note that chitosan stimulates the development of the root system, improves the efficiency of water and individual elements' uptake by roots, which in turn is associated with the intensification of plant growth [15, 33-35]. It has been reported the coating in oligochitosan of twin scale *Eucomis comosa* cuttings of the cultivar 'Sparkling Burgundy' and 'Twinkly Stars' resulted in a better development of the root system [10]. It should also be noted that the action of biostimulants depends to a large extent on the genotype, concentration, method of application, as well as the interaction of many external factors, such as climatic conditions and soil properties.

4. CONCLUSION

The results obtained allow to conclude that application of chitosan will enable shortening the production cycle and obtaining high quality *Eucomis bicolor* plants. Chitosan at 50 mg/L has a stronger effect on the increase of the number of leaves per plant, the relative chlorophyll content in the leaves as well as the number of bulbs per plant than chitosan at 100 mg/L. The publication included in the scientific achievements present a number of new informations on the possibilities of using environmentally friendly chitosan to improve the growth of *Eucomis bicolor* plants. Furthermore, chitosan can be recommended in sustainable cultivation programs, where particular emphasis is placed on reducing the use of pesticides and fertilizers that have a negative impact on the environment.

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