Plant biostimulants in horticulture: Recent advances and challenges ahead

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Abstract
Agriculture must meet the twin challenge of feeding a growing global population, while simultaneously minimizing the environmental impact of cropping systems. In other words, new farming practices should be introduced in order to produce more food in a sustainable way. One of the most promising and innovative technologies to tackle these rising challenges consists in the use of plant biostimulants which include substances and/or micro-organisms, other than fertilizers and pesticides, able to promote plant growth, yield and to improve produce quality as well as resource use efficiency when applied to the crop in low quantities. The present review intends to reflect the recent advances on plant biostimulants from different points of view (agronomical, physiological and biochemical) in order to integrate the use of plant biostimulants as an effective mean for sustainable horticultural production. This article describes the emerging definitions of plant biostimulants and reviews the different categories (microbial and non-microbial plant biostimulants) as well as their mode of actions. The impact of two categories of plant biostimulants protein-hydrolysate and seaweed extracts as well as the effects of beneficial micro-organisms in particular *Trichoderma* spp. on the metabolism and physiology of greenhouse leafy (spinash, rocket and lettuce) and fruit vegetables (tomato and zucchini squash) will be also covered. Finally, the review identifies several future research areas relevant to plant biostimulants to exploit and improve the biostimulant effects in greenhouse vegetable crops.