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Water Use Efficiency on Cabbage and Cauliflower Treated with a New Biostimulant Composition

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Abstract

We developed a new plant biostimulant composition, containing low doses of sodium selenate, glycine betaine and a spray adjuvant. We performed an experiment to test the influence of treatments with this new biostimulant composition, on cabbage and cauliflower crops, cultivated under normal watered and water stress conditions. We aimed to prove that an efficient technology of protective biofortification with selenium of crops would solve two technical problems of cruciferous cultivation into a semi-arid area, with selenium soil deficit: (i) safety supplementation of food chain and, concomitant, (ii) enhanced water use efficiency. Normal watered plants were irrigated at a rate of 100% crop evapotranspiration (ETc). Water stressed cabbage and cauliflower plants were irrigated under deficit conditions, at a 75% ETc. Six different treatments, including the new biostimulant composition and its ingredients, separate and/or in combination, were applied on cabbage and cauliflower, in a field experiment, organised in split plot design, with three replications. The treatments were applied by foliar spraying, 3 weeks and 6 weeks after seedlings transplantation in the field. During vegetation, physiological parameters (chlorophyll a fluorescence and stomatal conductance) were assayed. After harvesting, yield parameters were determined, for each treatment applied to both normal watered and water stressed plants. We calculated the water use efficiency as ratio between the marketable yield and the water used. We tested in field conditions this new biostimulant composition, which allows to obtain, under conditions of moderate water stress, a marketable production similar to that of the normal watered crop. Physiological parameters demonstrated also enhanced water-use efficiency on cabbage and cauliflower treated with the new biostimulant composition, containing sodium selenate, betaine and spraying adjuvant based on ethyl rapeseedate.

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Keywords: selenium, betaine, water use efficiency, cabbage, cauliflower.

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1. Introduction

Plant biostimulants represent an emerging class of agricultural / horticultural inputs, which promote plant growth, modulate plant development, enhance yield characteristics and increase crop tolerance to abiotic stress (Calvo et al., 2014, Bulgari et al., 2015).

Selenium is an essential element for humans (Fairweather-Tait et al., 2011, Rayman, 2012, Roman et al., 2014). However, selenium is also a highly toxic element (Jablonska & Vinceti, 2015), with a very narrow safe physiological window (Rayman, 2012). In area with deficiency on soil, selenium treatments were applied on crops, for a safer food chain biofortification (White & Broadley, 2009). The evidences accumulated in the last two decades demonstrate that selenium, in low doses, is acting also as a plant biostimulant, promoting plant growth (Malik et al., 2011), increasing cultivated plant resistance to abiotic stress (Pilon-Smits et al., 2009, Feng et al., 2013, Sieprawska et al., 2015), including drought (Ahmad et al., 2016), and enhancing accumulation of bioactives into edible parts of treated plants (Malagoli et al., 2015).

Due to chemical similarities, selenium interfere with sulfur metabolism (Sors et al., 2005, Zhu et al., 2009). This interference is particularly important for *Brassicaceae* plant, wherein sulfur secondary metabolites (e.g. glucosinolates) are important for both plant response to stress (Martinez-Ballesta et al., 2013) and human health (Traka & Mithen, 2009).

Methionine is one of the sulfur-related metabolic pool which is affected during selenium assimilation in plant (Fofana et al., 2014), being over-used during seleno-amino acids methylation, through S-adenosyl-methionine (Tagmount et al., 2002) and S-methylmethionine cycles (Lyi et al., 2007). We proposed the use of glycine betaine (GB) together with selenium, for the re-equilibration of sulfur metabolism in treated *Brassica* plant (Oancea et al., 2015). GB support (re)methylation of homocysteine to methionine in humans cells (Pajares & Perez-Sala, 2006) and was proved to act also as a methyl donors in plants (Baburina & Shevyakova, 1995). We tested the combination of selenium salts and GB in laboratory conditions, on cabbage seedling, as foliar treatment, with positive results (Oancea et al., 2015), optimizing the ratio between sodium selenate - GB.

One of our aims for this work was to verify into a field experiment these laboratory results. An additional aim was to test on field conditions the plant biostimulant effects, related to water stress tolerance / water use efficiency, of sodium selenate – GB mixture, which associate GB, a plant osmoprotectant / compatible solute, considered to act mainly at molecular level (Ashraf & Foolad, 2007), with a salt of an element, Se, increasing plant tolerance to drought through physiological modifications (Ahmad et al., 2016). Selenium and betaine are included into plant biostimulant categories, recently reviewed for horticultural use (du Jardin, 2015). However, their combination was not yet tested on experimental field conditions.

Both sodium selenate and GB are applied at low doses, which do not generate enough concentration gradient as a driving force, according to Fick's law, for a fast stomatal pores passive diffusion (Fernandez & Eichert, 2009). A practical solution for an improved uptake of foliar applied selenium salts and GB should be agricultural spray adjuvants, which function are to increase foliar uptake of hydrophilic / polar solutes through plant cuticle (Heini et al., 2012, Castro et al., 2014). Another aim of our work was to establish the influence of an agricultural spraying adjuvant, based on ethyl rapeseedate, lecithin, ethanol, glycerol and fatty acids salts, on the efficacy of sodium selenite – GB mixture and/or its components.

Our focus was on water use efficiency (WUE), on cabbage and cauliflower cultivated on an area of Romania, Bărăgan Plain (South-East of Romanian Plain), characterized by an multi- annual climatic water deficit of – 300 mm (Paltineanu et al., 2009). Cauliflower and especially cabbage are important horticultural crops for this area (Popescu, 2013). Both cabbage and cauliflower are classified among vegetables crops with intermediate susceptibility to water stress (Smittle et al., 1994, Kage et al., 2004, Xu & Leskovar, 2014). Because of increasing water costs, management of crop water productivity/water use efficiency for such crops into semi-arid area is important for a better profitability (Geerts & Raes, 2009, Xu & Leskovar, 2014).

The final aim of this work was to prove that an efficient approach of protective biofortification with selenium of crops could solve two technical problems of cruciferous cultivation into semi-arid area, with selenium soil deficit: (*i*) safety supplementation of food chain and, concomitant, (*ii*) enhanced water use efficiency.