Supplementation of calcium increases the growth and pigment content in *Solanum melongena* exposed to metal stress

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Abstract:

The present study deals with the cadmium toxicity in plants and the role of calcium in alleviating the Cd toxicity and increasing plant growth and enhancing pigment content and increasing the content of bioactive compounds such as protein which ultimately enhances the growth and productivity of plants and provide tolerance against heavy metal stress.

Key words: Growth; photosynthetic pigment; growth; calcium

Introduction

Heavy metal (HM) refers to elements with a specific gravity greater than 5.0, but biologists often use the term to refer to a wide range of metals and metalloids that are toxic to plants at certain concentrations, such as copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), nickel (Ni), cobalt (Co), cadmium (Cd), arsenic (As), and so on. Heavy metals (HMs) have a negative impact on plant life and growth. Plants require some HMs as necessary micronutrients, such as Fe, Mn, Zn, Ni, and Cu, while others, such as Hg, As, and Cd, are poisonous and non-essential (Polle and Schutzendubel, 2003). Cadmium (Cd) is a chemical element with the atomic number 48 and is a member of group 12 that is mostly discharged into the soil, water, and air through natural and anthropogenic sources. Atmospheric deposition via volcanic eruptions, forest fires, the creation of sea salt aerosols, and other natural occurrences (Nagajyoti and Sreekanth, 2010), as well as direct application methods such phosphate fertiliser use and sewage sludge disposal, are the main sources of cadmium in soil.

Cadmium interferes with a variety of physiological and biochemical processes in plants, including photosynthesis, respiration, and nitrogen metabolism, causing poor growth and low biomass accumulation (Sanita di Toppi and Gabbrielli, 1999; ArasimowiczJelonek 2011). However, exogenous mineral nutrient supplementation, particularly calcium (Ca), promotes plant growth and productivity by increasing root and shoots fresh mass, as well as increasing pigment content, which increases photosynthesis rate and also increases the content of bioactive content such as protein and carbohydrate in plants. Thus the present study has been performed to see the impact of supplementation of Ca on growth productivity of planted exposed to Cd stress.

Materials and Methods

Plant growth and conditions

Seeds of *Solanum melongena* (Brinjal) purchased from certified seed agency of Agra, Uttar Pradesh. After sterilization with sodium hypochlorite the seeds were washed thrice with distilled water and kept in dark. The germinated seeds were then shifted to plant growth chamber under controlled humidity and temperature under 300 μmol photons $m^{-2}s^{-1}$.

Selection of doses

Following 15 days of acclimatization, uniform sized seedlings were exposed to Cd stress i.e. (20 ppm) pointing to LC 30. The, over all set- up comprises of (i) control (ii) 20 ppm Cd (iii) Ca (iv) Cd+Ca. All the experiments were done after 8 days of seedlings growth. The Ca at 10 µM promoted (20%) growth that was selected for the study.

Growth behavior

Growth was determined by analyzing fresh mass.

Total chlorophyll content

The total chlorophyll content (Chl *a* + Chl b) and carotenoids (Car) were estimated by following the method of Lichtenthaler (1987).

Protein content

The estimation of protein content was done by following the method of Lowery et al., 1981.

Statistical analysis

Duncan multiple range test (DMRT) was performed for the significant differences among treatments at $P<0.05$ levels.

Experimental findings

3.1. Growth

Figure 1 shows the outcomes connected to growth. The data clearly show that under Cd stress, the growth of the tested seedling was considerably impaired, declining by 30% when compared to the control. However, exogenous Ca supplementation reduced the detrimental effects of Cd stress: Ca alone increased growth by 20%, and when combined with a Cd dose, the toxicity was reduced by 11%. Ca appears to play a helpful impact in decreasing Cd stress in plants.

3.2. Total chlorophyll content

Figure 2 shows the pigment composition, which includes total chlorophyll and carotenoids. The results show that the total Chl content was reduced by 31% under a specific Cd dose, while the Car content was reduced by 22% in comparison to the control. Exogenous Ca supplementation alone increased total Chl and Car content by 10% and 6%, respectively, and when combined with a Cd dose, the toxicity was reduced, i.e. Ca caused an increase in pigment content under comparable conditions, but only a 15% and 9% reduction in total Chl and Car.

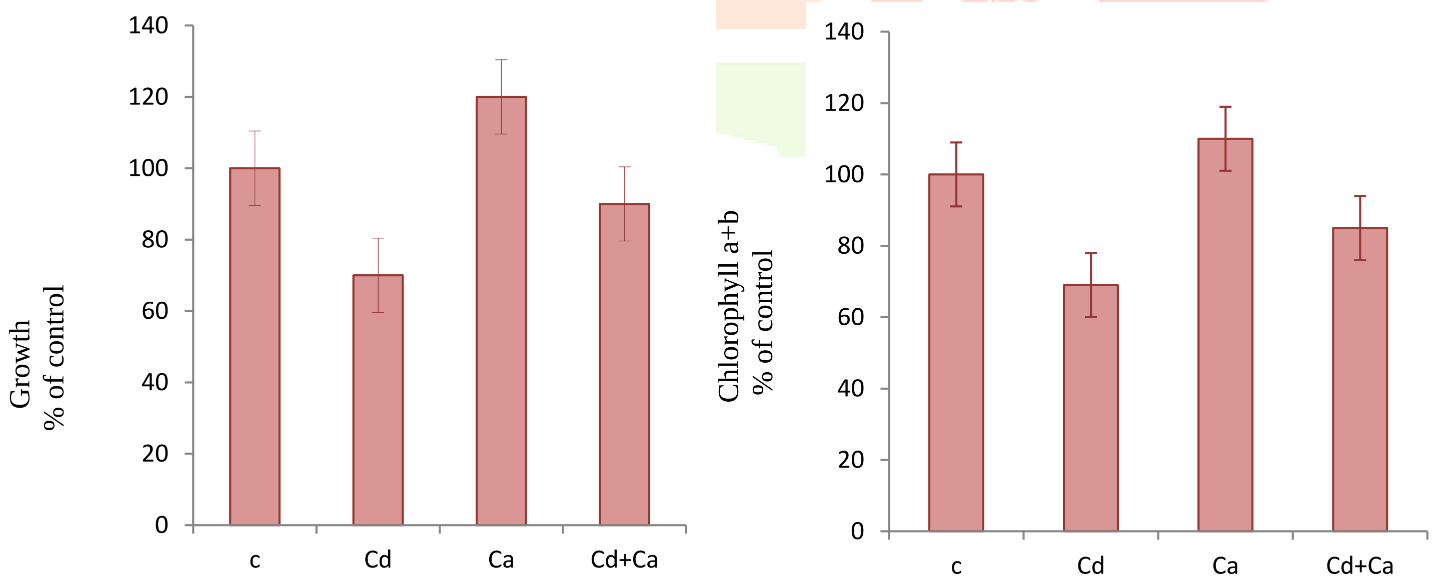

Figure 1and 2. Growth of *Solanum melongena* seedlings under Cd stress supplemented with or without Ca. Data are presented in form of % of control where 100% of control corresponds to 0.104 g/plant fresh weight and 1.62 mg (g FW^{-1}) for total chlorophyll.

3.3. Protein content

The protein content result, as shown in Figure 3, clearly reveals that under Cd toxicity, protein content decreased by 18%. However, exogenous Ca supplementation alone increased protein content by 12%, but combination treatment with Cd reduced protein amount by only 9%. Thus, focusing on the beneficial side of Ca in reducing Cd-induced toxicity.

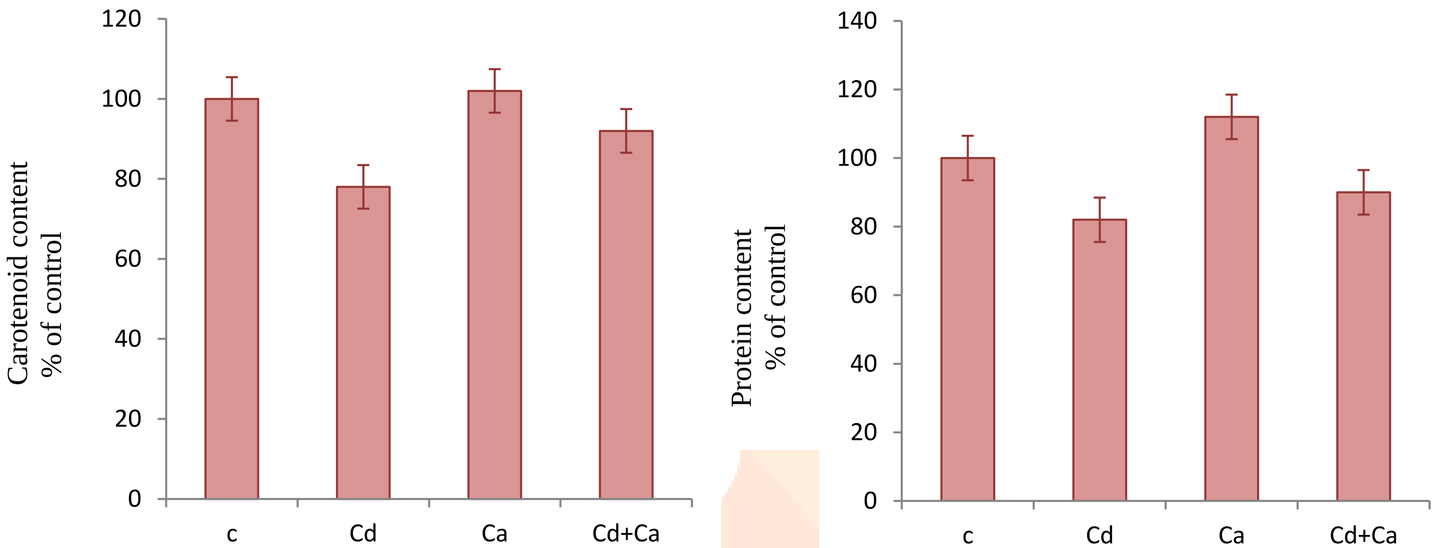

Figure 3 and 4. Growth of *Solanum melongena* seedlings under Cd stress supplemented with or without Ca. Data are presented in form of % of control where 100% of control correspond to 0.31 mg (g FW^{-1}) and 3.5 mg g^{-1} FW of Carotenoid and protein content respectively.

4.0. Discussion

The current research focuses on the effect of calcium in reducing Cd toxicity in crop plants, specifically Solanum melongena. The Cd toxicity resulted in a significant reduction in growth (Figure 1), which is linked to increased Cd accumulation, which causes damage to photosynthetic pigment content (Figure 2) and protein content (Figure 3), altering photosynthesis rates and disrupting electron leakage, which eventually leads to oxidative stress equivalent to our conclusions studies have also been stated by Gill et al., (2012). Clemens et al., 2002 also reported parallel decrease in growth under Cd stress. The photosynthesis rely upon the eminence of the photosynthetic pigment,(Chl *a* and Chl b) which are essential whereas Car is a accessory pigment and involved in photo protection. Under Cd stress the photosynthetic pigment content pointedly declined due to replacement of co-factors required for the Chl biosynthesis or degradation of enzyme involved in chlorophyll synthesis (Barcelo et al., 1986),thus modification in pigment content and photosynthetic activity might be the possible motive for the reduction in growth. The reduced photosynthetic efficacy points towards the leakage of electron and eventually generation of reactive oxygen species (ROS). Exogenous Ca supplementation, on the other hand, significantly improved plant growth and productivity. Thus, supplementing Ca with Cd stress balances the nutritional level in plants, which may be the cause of increased chlorophyll content, carotenoids, and photosynthetic repair. As a result, plant growth will be improved.

5.0. Conclusion

According to the findings, Cd toxicity significantly lowered the growth of Solanum melongena due to increased Cd accumulation, decreased pigment content, and increased oxidative stress, which eventually leads to cell death and lower crop production. Ca supplementation significantly improved the growth of the studied plant by reducing Cd accumulation, as well as decreasing pigment content, protein, and oxidative stress. As a result, the study concludes that Cd toxicity in plants can be reduced by using Ca to boost plant growth and productivity under heavy metal stress.

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