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Vitamin or salicylic acid treatments versus the adverse effects of copper stress on photosynthesis and some related activities of wheat seedlings

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Introduction

Copper is an essential microelement in biological systems, participating in a number of physiological processes as a cofactor or as part of the prosthetic group of many enzymes, primarily oxidoreductases (Clarkson and Hanson, 1980). Excess copper may result in membrane damage (Kennedy and Gonsalves, 1987), suppression of enzyme activity (Walker and Webl, 1981), cell death (Meyer and Heath, 1987) and inhibition of both light reactions of photosynthesis (Lanaras *et al*., 1993).

In autotrophic organisms, although it is well known that vitamins are endogenously synthesized (De Gara *et al*., 1993), yet exogenous application of these organic compounds exerted mostly positive effects on plant growth, CO_2 uptake and protein synthesis (Arrigoni *et al*., 1997). Also, exogenous application of SA decreased the effects of low temperature, salinity stresses in some plants (Al-Hakimi and Hamada, 2001; Janda *et al*., 1999). Thus in the present work it is intended to follow the role of AsA, B_1 and SA treatment in protection of young wheat plant against excess Cu stress.

Materials and methods

Five-day-old wheat (*Triticum* aestivum L.) seedlings were grown hydroponically in aerated Hoagland solution in a green house under natural light for 2 weeks. Copper treatment was performed by supplementing the nutrient solution with an increasing concentration of copper ions in the form of $CuSO_4$ (5, 10, 20 and 40 mg L^{-1} Cu^{++}) and the plants were left for 3 days. Some of the plants were pre-treated with 100 ppm AsA, B_1 or SA as sodium salicylate added to the hydroponic solution for only 1day. At the end of the experimental period fresh shoots and roots were then dried in an aerated oven at 70C. The content of chlorophylls a, b and carotenoids were determined spectrophotmetrically (Metzner *et al*., 1965). Net photosynthetic rate and dark respiration rate were determined manometrically (Umbreit *et al*., 1959).

Results

An increase in Cu concentration from 5 to 40 mg L^{-1} resulted in a marked inhibition of seedling growth; both fresh and dry weights of shoot and root systems decreased (Fig. 1). Pretreatment with AsA, B_1 or SA resulted, in most cases, in a pronounced increase in the production of fresh and dry matter yields in shoots and roots of Cu stressed wheat plants as compared with those of untreated plants (Fig. 1).

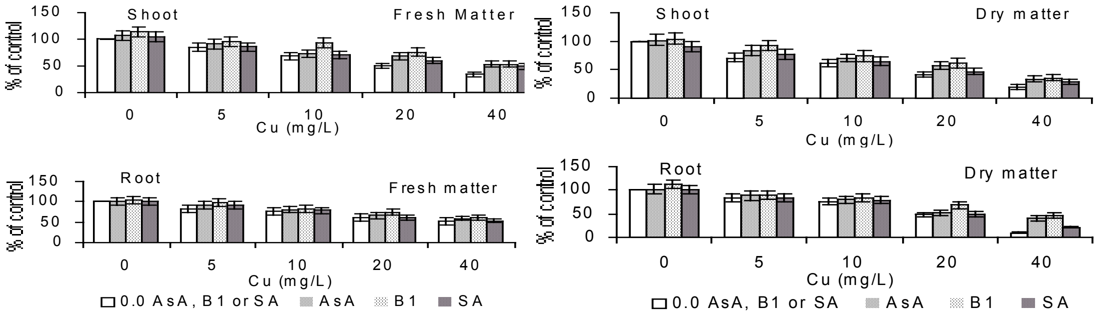

Fig. 1: The action of AsA, B_1 and SA treatments in amelorating the adverse effects of Cu stress on fresh and dry matter of shoots and roots of wheat plants. Values in parentheses represent +SD.

Also the retarding effect of Cu stress on the biosynthesis of pigments fractions (Fig. 2) was partially or completely alleviated in seedlings pretreated with the AsA, B_1 or SA.

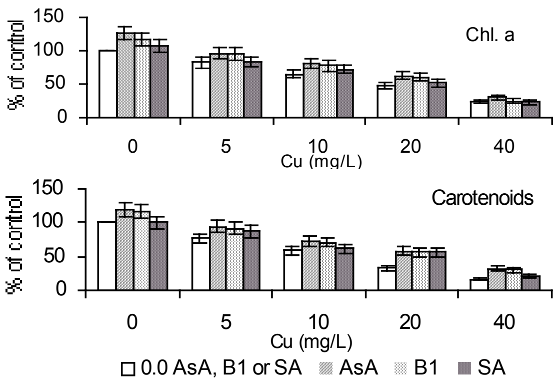

Fig. 2: The action of AsA, B_1 and SA treatments in ameliorating the adverse effects of Cu stress on photosynthetic pigments (chl. a, chl. b and carotenoids) of wheat plants. Values in parentheses represent ± SD.

Excess Cu in the nutrient solution retarded the photosynthetic O_2 evolution (Fig. 3). In case of AsA, B_1 or SA pretreatments the net photosynthetic rate approached or exceeded those of the control especially under the low levels of Cu. Respiration of all Cu stressed plants was markedly stimulated with the rise of Cu level. With the application of AsA or B_1, the low levels of Cu failed to stimulate O_2 consumption. However SA pretreatment enhanced the stimulatory role of Cu stress in activation of dark respiration (Fig. 3).

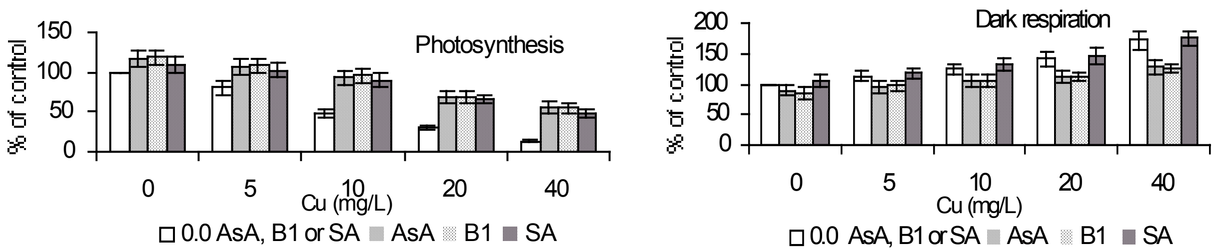

Fig. 3: The action of AsA, B_1 and SA treatments in ameliorating the adverse effects of Cu stress on net photosynthesis and dark respiration of wheat plants. Values in parentheses represent ± SD.

Discussion

The response of wheat plants to the high levels of Cu was reflected in a manifest decrease in shoot and root growth. Vitamins or SA pretreatment alleviated completely or partially the adverse effects of Cu on growth of wheat seedlings. This means that each of the two vitamins or salicylate may act as a growth stimulant, which can play a role in reversing the effect of Cu on metabolic activities relevant to growth, like cell division and cell enlargement (Woolhouse, 1983).

The inhibited pigment biosynthesis due to Cu stress could be attributed to increased leaf senescence. Pretreatment of the seedlings with any of the two applied vitamins or SA alleviated this inhibitory effect, which may contribute directly to the effectiveness of the photosynthetic apparatus. In accordance with this, it was found that chloroplasts isolated from leaves, which were previously sprayed with AsA showed higher contents of chlorophylls than those isolated from untreated leaves (Choudury *et al*., 1992). Similarly, foliar application with B_1 helped some bleached plants resynthesise chlorophyll and consequently exerted positive effect on plant growth and productivity (Oertli, 1987).

The results of the present work and those obtained by other investigators (Maksymiec and Baszyski, 1996) clearly demonstrate that high applications of Cu inhibit the photosynthetic activity. These results were generally accompanied by reciprocal variations in the dark respiration activity (stimulated). Seedling pretreatment with AsA, B_1 or SA was generally effective in antagonizing partially or completely the inhibitory effects of Cu stress on the net photosynthetic rate. On the other side, the stimulatory effect on the dark respiration rate with the rise of Cu level, could be regarded as a repairing system for the cellular damage linked in some way to the suppression of growth (Lambers, 1979). On the contrary, pretreatment with SA enhanced the stimulatory effects of Cu stress on dark respiration of seedlings. These increased values of dark respiration rate indicate that SA could provoke alteration very often associated with plant responses to stressful conditions (Rhoads and McIntosh, 1991).

From the preceding results and discussion, it can be concluded that pretreatment of wheat seedlings with AsA, B_1 or SA could alleviate the inhibitory effects of Cu stress and also stimulate the growth *via* enhancement of the photosynthetic rate.

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