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Effects of IAA and IAA precursors on the development, mineral nutrition, IAA content and free polyamine content of pepper plants cultivated in hydroponic conditions

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Abstract

The effect of IAA and two IAA precursors, L-tryptophan (Trp) and indole (Ind), on the growth, mineral nutrition and potential development under stress conditions of intact pepper plants cultivated in hydroponic conditions, has been studied.

To this end, the growth of both shoots and roots, the plant content of both IAA and free polyamines and the content in leaves and roots of macronutrients and micronutrients have been evaluated.

Both Trp and Ind presented a similar pattern of action to that of IAA regarding both plant development and mineral uptake. The application of Ind and Trp at the highest dose (10^{-3} M) was associated with significant increases of IAA content in roots. The application of IAA and IAA precursors was associated with an increase in Spermine and a decrease in Putrescine in leaves, thus suggesting the conversion of Putrescine into Spermidine and Spermine, which in turn could be associated with better plant development under stress.

Both Trp and Ind showed auxin-like effects likely due to their conversion into IAA within the plant. However, further studies carried out under axenic conditions are needed in order to clarify this question.

Keywords: IAA; Tryptophan; Indole; Free polyamines; Plant growth; Mineral nutrition; Pepper; Hydroponics

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1. Introduction

Abiotic stress, such as drought or salinity, is one of the most important problems faced by intensive crops cultivated under greenhouse conditions in Mediterranean countries (Alpi and Tognoni, 1990). Furthermore, in the case of hydroponic or inert-substrate (siliceous sand, perlite, ...) cultures, pernicious effects caused by these stresses are aggravated by yet more important problems in both root growth and the regeneration of adventitious roots and root hair formation (Moe and Anderson, 1989; Hartmann et al., 1990; Resh, 1991). This is mainly related to the absence of the beneficial root–microorganisms interactions that occur in the rhizosphere (Pinton et al., 2001), the negative effects on the plant uptake of certain nutrients, principally Ca (Marschner, 1995) and the increase in the biosynthesis of certain stress-related plant hormones, mainly abscisic acid (ABA), that reduce in most cases the development of new lateral and adventitious roots (Trewavas and Jones, 1991; Blum, 1997). That is why, among other possible reasons, specific research is being developed which is oriented to achieve a deeper knowledge of those physiological processes involved in rooting, principally regarding the role played by different plant growth regulators in that process.

Thus, a number of studies have demonstrated the implication of IAA in the process of lateral and adventitious root formation (Meuwly and Pilet, 1991; Calenza et al., 1995; Arteca, 1996; Rahman et al., 2002). In fact, different formulations based on natural or synthetic auxins have been offered to farmers in order to enhance the development of new adventitious roots during the cycle of cultivation (De Liñan, 2003). In horticulture, however, the correct use of auxins is not always an easy task due to the coexistence in the same plant of different physiological states (for example, in pepper or tomato: flowering, fruit set and fruit ripening). A possible means of overcoming these constraints could be the use of precursors of the biosynthesis of IAA, so the plant itself would manage the appropriate biosynthesis and organ accumulation of IAA according to its needs, in order to avoid imbalances in its physiology. Among the different compounds involved in IAA biosynthesis, L-tryptophan (Trp) and indole (Ind) seem to be good candidates as IAA precursors (Slovin et al., 1999). In fact, the plant capability to convert Trp into IAA has been well established in a great number of plant species and soil microorganisms (Arshad and Frankenberger, 1998; Slovin et al., 1999). Furthermore, recent studies have also reported that plants have a pathway that includes Ind but not Trp as a precursor of IAA biosynthesis (Slovin et al., 1999). Thus, although specific works on the agricultural usage of Ind were not found in the literature, a number of studies have demonstrated the positive effect of Trp treatment on the yield and quality of a number of crops cultivated in different soil types: Douglas fir (Frankenberger and Poth, 1987), radish (Frankenberger et al., 1990), melon (Frankenberger and Arshad, 1991a), pepper (Frankenberger and Arshad, 1991b; Kadiri, 1999) and rice (Zahir et al., 1999). Furthermore, complementary studies suggested that in all these cases Trp was transformed into IAA in the rhizosphere by soil microorganisms before being taken up, rather than assimilated directly by plants. Thus, Martens and Frankenberge (1994) have observed very poor uptake of labelled Trp compared with labelled IAA by wheat seedling roots. Likewise, they also reported a very low endogenous conversion of exogenously applied labelled Trp into auxins by wheat seedlings growing under axenic conditions. In contrast, Lovatt (2001) recently reported the