ROLES OF POLYAMINES IN PLANTS
GROWTH AND STRESS: IN VITRO CULTURE IMPLICATIONS

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AIMS OF THIS WORK
i. Describe the main characteristics and functions of polyamines in plants.
ii. Elucidate the implications of PAs in growth in in vitro shoot culture.
iii. Explain how can PA participate in stress responses.

INTRODUCTION[1]

- Definition: polyamines (PAs) are low molecular weight, aliphatic polycations found in the cells of all living organisms.
- In plants, the three major PA are putrescine (Put), spermidine (Spd) and spermine (Spm).
- Functions: in plants, PAs play important roles in morphogenesis, growth, embryogenesis, organ development, leaf senescence, and abiotic and biotic stress response.
- Biosynthesis: almost all eukaryotes synthesize Put directly from ornithine. In plants, two alternative pathways to PA biosynthesis exist, catalysed by ornithine decarboxylase (ODC) and arginine decarboxylase (ADC).
- Growth culture: manipulation of cellular PA pool can be employed as a strategy to control vegetative growth of fruit trees, but first it is necessary to know how this perturbation of PA affects shoot growth.
- Stress culture: cells of soybean cotyledon-node callus have abundant soluble proteins with high CuAO activity, a copper amine oxidase gene involved in NO release.

DISCUSSION AND RESULTS

GROWTH

PA are necessary for cell growth[1]:
- PA influence flowering, cell division, and other developmental processes at different stages of plant development.
- Crosstalk between PAs and hormones such as gibberellins, auxins, and ethylene, are demonstrated.
- The intrinsic mechanisms underlying such actions are not completely established.

Correlation between free polyamines and growth of apple in vitro shoot callus[2]:
- D-arg (an inhibitor of ADC) significantly reduced the net increase in fresh weight and PA levels in a 3-week treatment (Fig. 1, 2).
- Addition of exogenous Put partially resumed the growth at 1 mM, and gave rise to a significant increase in fresh weight at 5 mM, higher than the control every week (Fig. 1).
- Transcription levels of key genes involved in PA biosynthesis (MdADC, MdSAMD2, MdSPDS1 and MdACL5), were suppressed by D-arg treatment. Exogenous addition of 5 mM Put could enhance their expression.
- Possible mechanisms of action of PA:
  - Growth limiting by acting as a nitrogen provider.
  - Mediating hormone effects at cellular levels and acting as second messengers. Interacting with phytohormones that are important in cell division.
  - A fluctuation of a component of the PA biosynthetic pathway result in a coordinated alteration of several genes involved in the biosynthesis, suggesting a tight homeostatic regulation of cellular PA.
  - D-arg may be possibly used as a growth controlling compound for fruit trees.

STRESS

PA, ABA and NO participate in plant responses to biotic and abiotic stresses[3]:
- The crosstalk between PAs, ABA and NO form a complex integration that is responsible for downstream stress responses, like ROS production, ion channels modulation (ion homeostasis), amino acid and carbon metabolism (osmotic balance), and stomatal response (keeping of water status), among others.
- NO production in suspension cells of soybean cotyledon-node callus[4]:
  - PAs significantly induced NO release (Fig. 3, 5).
  - When L-AG (diamine oxidase, DAO, inhibitor) was added, NO fluorescence was diminished (Fig. 3).
  - H2O2 contents increased after the addition of PA, and when H2O2 levels were reduced using CAT, the PA-induced NO release was diminished (Fig. 3).
  - DAO activity was promoted with exogenous application of PAs (Fig. 4).
  - Possible mechanism for NO release:
    - Conversion of PA by oxidases to generate NO.
    - H2O2, required in PA-induced NO generation, might be derived from PA oxidative degradation.

CONCLUSIONS:
- Polyamines are necessary for a correct growth of callus cells of plants, and they participate in stress responses.
- In apple in vitro shoots, polyamine depletion led to growth retardation.
- Two possible mechanisms of action are proposed: acting as a N provider, or interacting with phytohormones. A tight homeostatic regulation exists.
- PAs induce NO release in soybean cotyledon node callus, which plays a pivotal role as messenger to induce biotic and abiotic stress responses. DAO could be involved in PA-induced NO generation and H2O2, required for this process might be derived from PA oxidative degradation.
- It still remains unclear the molecular mechanisms by which PA act, and further investigation is required.

REFERENCES: