Modification of NH^{+} ions transport into *Zea mays* germ roots by means of exogenous amino acids

Anatolij P. Kudrjashov[1], *Tat'jana Tsap*[2]

[1]Belarusian State University, 220030 Nezavisimosti Avenue 1, Minsk, Republic of Belarus
[2]Mogilev State University of Food Production, 212027, Schmidta Avenue 3, Mogilev, Republic of Belarus

Corresponding author: Tat'jana Tsap, email: tsaptanya@rambler.ru; tel: +375297620034

ABSTRACT

Influence of certain amino acids on ammonium uptake by corn shoots' roots was investigated.

Short-term treatment of roots with amino acids resulted in changes of ammonia transport into plant roots. Maximum inhibition of ammonia transport system was observed upon addition of D- and L-Asp, L-Gln, and L-Glu into experimental solution.

Changes in ammonium transport into seedling roots of *Zea mays* are caused by changes in qualitative and quantitative contents of amino acids in cell cytoplasm after treatment of seedling roots by exogenous amino acids.

KEYWORDS: *Zea mays*, ammonium transport, free amino acids

INTRODUCTION

Ammonium uptake systems have been found and characterized in the majority of plants including agricultural ones. Nitrogen compounds' transport rates into plant cell are constantly changing due to environmental (temperature and oxygen concentration in the radical zone, light, etc.) (Camanes, 2007; Malagoli, 2004; Wang, 1993) and metabolic factors. Latest research in this field points out to the existence of an internal "sensor of nitrogen" which controls processes of mineral nitrogen compounds' transport. Still it is not clear what substances fulfill this function. Nowadays it is widely believed that amino acids and amides play the main role in regulation of ammonium transport into plant cells (Miller, 2007; Glass, 2002).

METHODS

Corn seedlings (breed Porumben 270, moldavian selection) were cultured in water culture during 10 days in Knop medium.

Ammonium ions uptake was investigated be measuring the decrease of NH_4^{+} level in the medium. Concentration of ammonium in the medium was estimated by phenol-indophenolic method.

Qualitative and quantitative composition of free amino acids was measured in ethanol extracts by means of chromatograph Agilent 1200: G1312A (columns Zorbax Eclipse-AAA (3,0 x 150 mm x 3,5 µm)).

RESULTS AND DISCUSSION

Changes in ammonium transport dynamics were observed upon short-term (15-30 minutes) treatment of corn shoots’ roots with sulphur-containing amino acids. Ammonium transport system (ATS) activity was partially inhibited by exposing corn roots to 10^{-2}-10^{-3} M Met and $3 \cdot 10^{-2}$ M Cys solutions. Treatment of roots with 10^{-2} M Cys solution did not significantly activate ATS performance. Analysis of corn seedlings’ amino acid content revealed 3x increase in Gln concentration, while Cys level in control and treated groups remained constant (table 1). Such an effect of Cys and Met on ATS may be explained by involvement of sulphur-containing amino acids into glutathione metabolism with subsequent Gln synthesis.

Table 1. Concentration of amino acids in plant roots

Amino acids (plant roots treatment), mol/l	Concentration of amino acids in plant roots, mg/100g of wet weight						
	Met	Cys	Gln	Glu	Asn	Asp	Total amino acid concentration
Control (active ATS)	6,41±0,22	25,4±0,06	8,5±0,01	1,28±0,05	2,28±0,13	9,1±0,65	104,95±1,21
L-Met, 10^{-2}	7,15±0,16	22,35±0,17	22,28±0,06	3,4±0,02	10,3±0,07	3,65±0,06	98,7±1,14
L-Cys, $3 \cdot 10^{-3}$	–	28,77±0,12	72,82±0,1	1,12±0,07	54,66±0,08	3,59±0,09	242,82±0,9
L-Glu, 10^{-2}	2,82±0,06	22,57±0,12	29,69±0,56	2,21±0,03	24,0±0,2	2,88±0,04	110,1±1,6
L-Glu, 10^{-3}	4,7±0,09	24,5±0,15	15,4±0,12	17,6±0,31	6,7±0,04	10,8±0,4	106,1±1,9
L-Gln, 10^{-2}	5,43±0,12	23,21±0,12	24,9±1,42	1,9±0,17	27,99±0,4	1,24±0,09	134,54±0,9
L-Asn, 10^{-2}	2,56±0,3	22,53±0,6	35,1±0,4	–	39,3±0,12	12,89±0,14	108,3±1,3

ATS performance was significantly inhibited by 10^{-2} M and 10^{-3} M Gln. Similar effect was observed upon treatment with 10^{-2} M Glu, but 10^{-3} M Glu did not cause any inhibitory effect.

Similar effects were observed in plants after treatment with 10^{-2} M Asn although in this case inhibition lasted for one hour. Significant influence of this amide on ATS activity was not observed if Asn concentration in pre-incubation medium was decreased to 10^{-3} M. ammonium transport rate was not decreased upon treating corn seedlings’ roots with L-Asp. However, 30 minutes exposition of corn roots to highly diluted D-Asp solution resulted in two and a half hours inhibition of ammonium transport. Such an effect can probably be attained to similar stereochemistry of D-Asp and L-Gln amide groups.

Analysis revealed changes in free amino acids content within cells in plants treated with amino acids and their amides. Plants with deactivated ATS showed high levels of amide nitrogen and Cys. At the same time absolute concentrations of Asn, Gln, Asp, Glu, and Cys are not ultimate regulators of ATS activity. The regulatory factor must be ratio between concentrations of certain amino acids (or their amides). Plants with deactivated ATS usually have a ratio 1/1 between Gln and Asn and a ratio about 1/1 between Gln or Asn and Cys (table 1).

REFERENCES

Camanes, G. 2007. Ammonium transport and CitAMT1 expression are regulated by light and sucrose in *Citrus plants*. J. of experimental botany 58, 2811–2825.

Glass, A.D.M. 2002. The regulation of nitrate and ammonium transport systems in plants. J. of experimental botany 370, 855–864.

Malagoli, P. 2004. Modeling nitrogen uptake in oilseed rape cv capitol during a growth cycle using influx kinetics of root nitrate transport systems and field experimental data. Plant physiology 134, 388–400.

Miller, A.N. 2007. Amino acid and nitrate as signals for the regulation of nitrogen acquisition. J. of experimental botany 59, 111–119.

Wang, M.Y. 1993. Ammonium uptake by rice roots II. Kinetics of $^{13}NH_4^+$ influx across the plasmalemma. Plant physiology 103, 1259–1267.