5^{o} COLLOQUIO INTERNAZIONALE SUL CONTROLLO DELLA NUTRIZIONE DELLE PIANTE COLTIVATE

5^{me} COLLOQUE INTERNATIONAL SUR LE CONTRÔLE DE L'ALIMENTATION DES PLANTES CULTIVÉES

5th INTERNATIONAL COLLOQUIUM ON THE CONTROL OF PLANT NUTRITION

25 - 30 Agosto 1980

CASTELFRANCO VENETO (Treviso)
Istituto Professionale di Stato per l'Agricoltura
via Postioma

INTERACTIONSHIP CHLORIDE-NITRATE ON NUTRITION OF TOMATO PLANTS.

by

Luque, A.[1], Carpena, O.[2], Cadahia, C.[2] and Palomino, E.[1]

SUMMARY.

Tomato plants vard "Marglobe" were cultivated in greenhouse by hydroponic system in order to study the effect of five treatments of Cl^-, 0, 8, 16, 24 and 32 $me.l^{-1}$ with five different concentrations of NO_3^- : 6, 12, 18, 24 and 30 $me.l^{-1}$. We found a cooperative effect of Cl^- and NO_3^- increasing concentration of both until 24 $me.l^{-1}$ of Cl^- and 18 $me.l^{-1}$ of NO_3^- which means an increase of NO_3^- in the nutrient solution thus decreasing the toxic effect of Cl^- in plants. Org N/NO_3^--N in the tissues is the index that best indicates its maximum growth, its value is considered to reach 1.0.

INTRODUCTION.

The presence of Cl^- in the irrigation water is one of the problems that affect arid and semiarid areas where there is a high evapotranspiration which produces salination in the soil.

Dropping irrigation allow the control of soil solution due to slow and continuous fertilization.

Tomato plants permit a concentration of Cl^- in nutrient solution of 15 $me.l^{-1}$ without decreasing its growth and production (Cadahia, 1968). The fertilization of tomato plants with high quantities of NO_3^- produces a decrease of Cl^- in the plant (Hernando et al. 1964). On the other hand the excess of Cl^- could produce a decrease in the NO_3^- content in the plant running the risk of inducing nitrogen deficiencies (Torres and Bingham, 1973).

Maas et al (1977) point out, using different sources, that -1.0 is the maximum osmotic potential tolerable in tomato plants.

Our work, therefore, focused in the study of Cl^- and NO_3^- relation in nutrient solutions, which allows the utilization of water with a high concentration of Cl^- by means of the increase fertilization of NO_3^-, as well as to find out to what extend Cl^- could affect assimilation, transporting and reduction of NO_3^- in tomato plants.

1) Departamento de Biología. Colegio Universitario de Las Palmas. Apartado 550. Las Palmas. ESPAÑA.

2) Departamento de Química Agrícola. Universidad Autónoma de Madrid. Madrid. ESPAÑA.

MATERIAL AND METHODS.

Tomato seeds (Lycopersicum esculentum vard Marglobe) were planted in volcanic sand. After 30 days, they were transplanted in pots containing volcanic sand with an inferior draining system. Five plants per pot were planted, two were recollected at the flowering time, two at fruiting time and the fifth on was picked two weeks later in order to determine the growth.

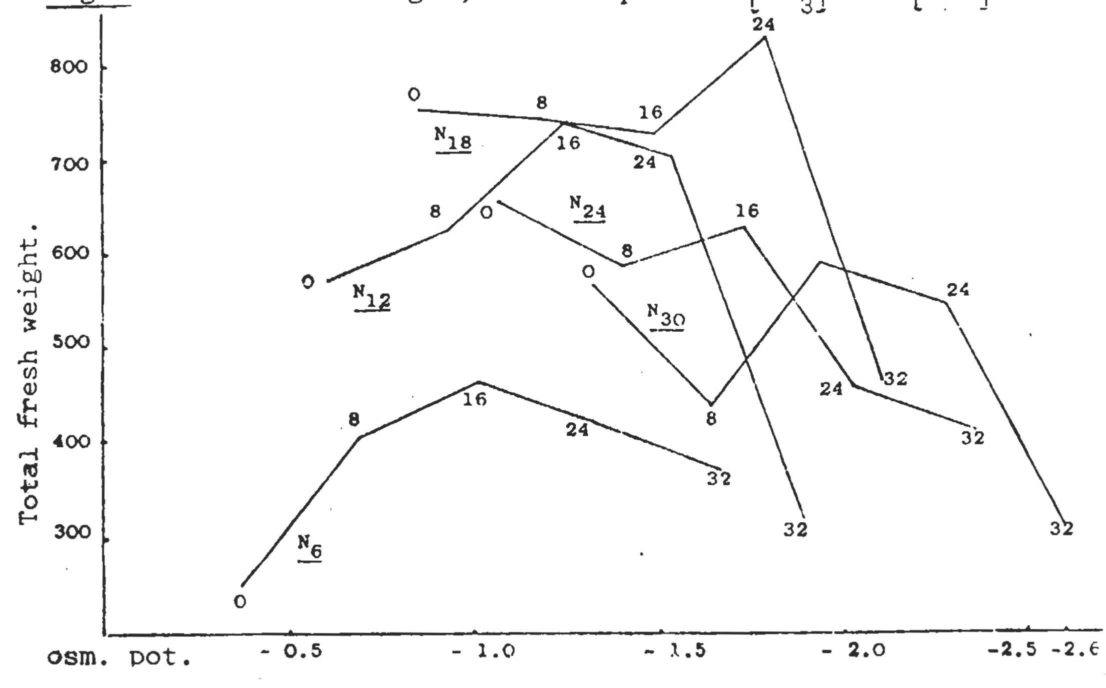
25 different treatments were conducted in the greenhouse, using five different concentrations of Cl^- (0,8,16,24,30 me.l^{-1}). Each treatment was repeated three times. Cations were kept at the same relative level (K : la : Mg = 0.35 : 0.45 : 0.20). H_2PO_4 and $SO_4^=$ were kept at the same absolute level (H_2PO_4 : 0.5 me.l^{-1}; $SO_4^=$: 3.5 me.l^{-1}).

Cl^-, NO_3^- and organic Nitrogen were analyzed in leaves, roots and stem juice at flowering time and fruiting time. Cl^- was determinated by extraction with water and valoration with silver nitrate (Ulrich and Johnson, 195). NO_3^- was extracted with water and determinated by Cataldo's method modificated in a higher concentration of salicilic acid in sulphuric acid (10% w/v), (Cataldo et at, 1975). Organic nitrogen was determinated by microkjeldahl method.

RESULTS AND DISCUSSION.

Fig.1 depicts as an index of growth the fresh weight of the complete plant with its fruits. We found and increase of growth with the increase of NO_3^- concentration in nutrient solution until 18 me.l^{-1}, and a cooperative effect of Cl^- up to 16 me.l^{-1} of Cl^- in nutrient solution with 12 me.l^{-1} NO_3^- and 24 me.l^{-1} of Cl^- with 18 me.l^{-1} of NO_3^-.In high concentrations of NO_3^- (24 and 30 me.l^{-1}) the cooperative effect oc Cl^- and NO_3^- disappears.

Fig.1.-Total fresh weight, osmotic pot.and $[NO_3^-]$ and $[Cl^-]$



A equilibrate relation of Cl^- and NO_3^- increases the resistence of the plant to lower osmotic potential, achieving the best results at -1.8. Higher concentrations produce a significative decrease of the growth.

Cl^- contents in leaves, roots and stems in flowering and fruiting time (Table 1) decreases when the NO_3^- concentration in nutrient solution increases. That decrease could be produced by the interaction of Cl^- and NO_3^- passing through tonoplaste at the entry in the cell vacuoles (Cram, 1973). The decrease of Cl^- facilitates a higher resistence of the plant to the specific toxic effect of Cl^-.

The toxic concentration of Cl^- in the stem juice for tomato plants has been pointed out by Cadahia (1968) in 118 $me.l^{-1}$ of Cl^- at flowering time and 140 $me.l^{-1}$ of Cl^- at fruiting time and he formed these values with 15 $me.l^{-1}$ of Cl^- in nutrient solution. In our experiment we found these concentrations in stem juice with 16 $me.l^{-1}$ of Cl^-,12 $me.l^{-1}$ of NO_3^- and 24 $me.l^{-1}$ of Cl -18 $me.l^{-1}$ of NO_3^- . This treatment ($Cl_{24}N_{18}$) is the best (Fig.1).

Values of organic Nitrogen change according to the type of the part of the plant and the sampling time. In the leaves at the flowering time there is a depressive effect of Cl^- with 6 and 12 $me.l^{-1}$ of NO_3^- in nutrient solution. This effect is significant between Cl 0 and Cl 8 treatments. This could be possible by a decrease in the malate sinthesis as a response to a high interne concentration of Cl^-, like it was pointed out by Schnabl and Raschke (1978) in stomatic cells, and that it would affect the absorption in roots and transport of NO_3^- to the shoots (Ben-Zioni et al, 1971).

In the leaves at fruiting time and in the roots at flowering time there is not a significative decrease of organic nitrogen values.

In the stem juice at flowering and fruiting time the depressive effect of Cl^- appears in higher concentrations of NO_3^- (18, 24, and 32 $me.l^{-1}$).

The relationship between org.N and NO_3^- - N (mg/mg) is the index that best agrees with the growth (Fig.2). We can see that this relationship increases with Cl^- up to 16 $me.l^{-1}$ of Cl^- in nutrient solution with 6 and 12 $me.l^{-1}$ of NO_3^- and 24 $me.l^{-1}$ of Cl with 18 $me.l^{-1}$ of NO_3^- .

Ferrari et al (1973) pointed out the existence of two different pools of NO_3 in the plant cell. One of them is the vacuolar pool (metabolically inactive) and the other one is the citoplasmatic pool (metabolically active).

The competition between Cl^- and NO_3^- to enter in the vacuola may induce a decrease of total NO_3^- in the cell, but the metabolic pool can increase, in which case it would allow to an increment in the reduction of NO_3 due to the fact that NO_3^- fluxes through the cytoplasme which regulates the activity of nitrate reductase (Shanner and Boyer, 1976).

This effect could be at the root level where we did not notice significant differences in organic nitrogen (see Table 2), due to the fact that the tomato plants may have a reduction of NO_3^- in roots (Suder-Moraw and Buczek, 1977). The reduced nitrogen could be translocated to the shoots.

Table 1

Cl^- contens L:leaves % d.w. R=roots % d.w. S=Stemjuice $me.l.^{-1}$

NO_3 $me.l^{-1}$ in nutrient solution		Cl^- $me.l.^{-1}$ in nutrient solution: 0		8		16		24		32	
		FL	FR	FL	FR	FL	FR	FL	FR	FL	FR
6	L	0.1	0.3	2.1	1.9	2.7	3.0	3.1	3.0	3.2	3.1
	R	0.6	0.4	2.7	3.1	3.3	3.4	4.2	4.4	3.6	3.6
	S	1.6	10	108	130	125	147	133	185	148	181
12	L	0.2	0.3	2.1	1.8	3.0	2.9	3.0	3.3	2.9	3.2
	R	0.6	0.4	2.6	3.2	3.3	3.5	3.7	4.3	3.2	3.7
	S	1.6	17.0	100	141	118	162	122	174	118	211
18	L	0.2	0.3	1.8	1.6	2.5	2.1	2.6	2.5	2.4	2.6
	R	0.5	0.4	2.6	2.8	2.9	3.0	3.6	3.3	3.0	4.0
	S	1.6	21	81	123	93.2	127	116	139	101	161
24	L	0.2	0.3	1.4	1.5	1.7	1.7	1.8	2.3	2.1	2.7
	R	0.5	0.3	2.3	2.1	2.5	2.6	2.5	4.3	3.0	3.8
	S	1.6	19	66	77	76	126	89	171	91	178
30	L	0.2	0.3	1.0	1.4	1.4	1.5	1.7	2.6	2.0	2.6
	R	0.5	0.4	1.7	2.2	1.8	2.1	2.7	4.0	3.1	3.9
	S	1.6	17	55	96	74	92	87	171	90.0	197

FL= Flowering time FR= Fruiting time

Table 2

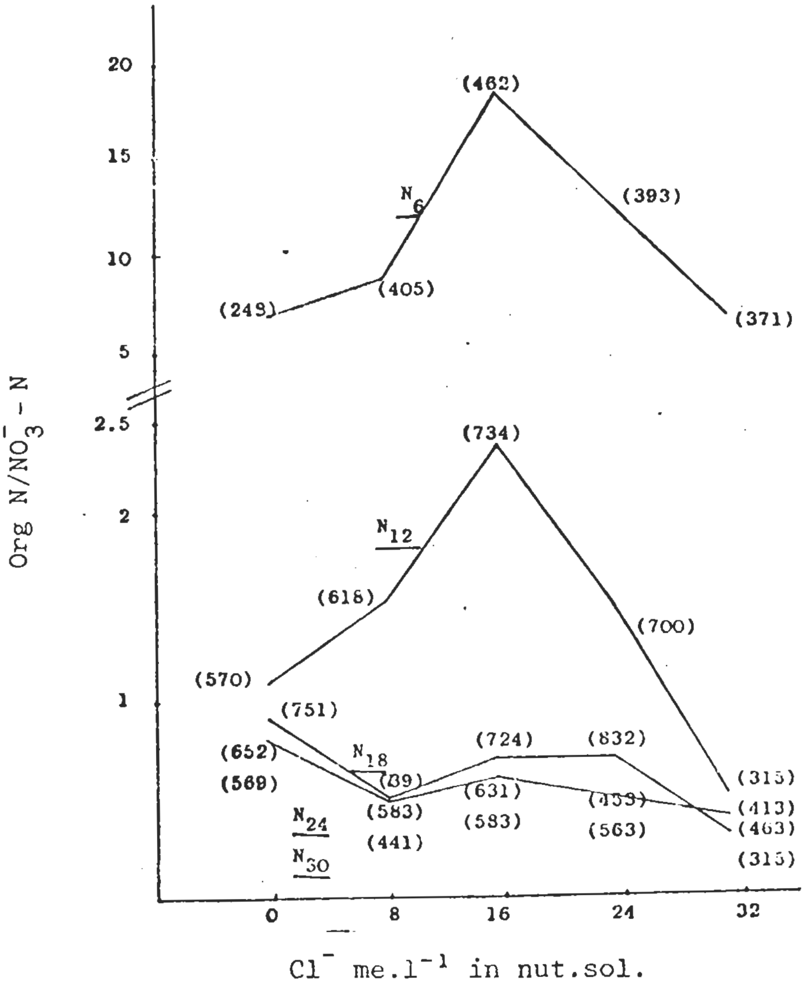
Org N. L=leaves % in d.w. R=roots % in d.w. S=Stemjuice $g.l^{-1}$

Cl^- $me.l.^{-1}$ in nutrient solution

NO_3 ($me.l^{-1}$) in nutrient solution		0 FL	0 FR	8 FL	8 FR	16 FL	16 FR	24 FL	24 FR	32 FL	32 FR
6	L	5.5	4.0	3.5	3.4	3.3	3.4	3.4	3.5	3.2	3.3
	R	1.7	1.8	1.6	1.5	1.7	1.5	1.8	1.5	1.8	1.6
	S	0.4	0.7	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
12	L	5.5	4.3	4.4	4.2	3.7	4.3	3.9	4.1	4.2	4.2
	R	1.7	2.2	1.9	1.8	1.7	1.8	2.0	1.9	2.3	1.8
	S	0.5	0.8	0.4	0.5	0.5	0.4	0.4	0.5	0.4	0.4
18	L	5.1	4.6	4.5	4.4	4.1	4.4	4.5	4.4	4.3	3.8
	R	2.3	2.3	2.1	1.9	2.4	1.9	2.1	2.0	2.3	1.9
	S	0.8	0.8	0.5	0.5	0.5	0.4	0.6	0.8	0.4	0.4
24	L	4.5	4.5	4.3	4.7	4.4	5.2	4.8	4.6	5.0	4.6
	R	2.4	2.2	2.0	2.0	1.9	2.2	2.1	2.2	2.3	2.4
	S	0.7	0.8	0.5	0.5	0.6	0.4	0.6	0.4	0.6	0.6
30	L	5.2	4.7	4.1	3.8	4.5	4.7	5.0	3.9	4.6	4.1
	R	2.3	2.7	2.3	2.6	2.4	2.3	2.6	2.1	2.2	2.3
	S	1.0	0.8	0.5	0.3	0.7	0.4	0.6	0.5	0.7	0.7

FL= Flowering time FR= Fruiting time

Fig.2.- Variation of the relation Organic N/NO_3^--N in stem juice at the flowering time (numbers in brackets are total fresh weights of each treatment).



CONCLUSIONS.

The increment of Cl$^-$ in the culture medium could be parcially mitigated by the increase of NO_3^- fertilization in the tomato culture.

In addition this enhances a better resistence to the effect of total salinity.

The cooperative effect of Cl$^-$ and NO_3^- could be explained by an increase of reduction in the roots and the translocation to the shoots of the reducted nitrogen.

The relation Org N/NO_3^--N in stem juice at flowering time is a good index to study the effect of Cl$^-$ in the NO_3^- metabolism and its value should be maintained next to 1.0. However, we believe that these results ought to be further studied in order to yield applicable results.

ACKNOWLEDGEMENT.

The authors are grateful to Dr.Angela García for her help in the translation and comments about this text.

LITERATURE

BEN-ZIONI, A., Y.VAADIA., S.HERMAN LIPS, 1971. Nitrate uptake by Roots as Regulated by Nitrate Reduction Products of the Shoot. Physiol. Plant., 24: 288-290.

CADAHIA, C., 1968. El análisis de Savia como índice de la influencia de los Cl^- en la nutrición de las tomateras. "Control de la Fertilización de las plantas cultivadas" (II.Coloquio Europeo Mediterráneo). 717-732. Sevilla (España).

CABALDO, D.A., HARRON, M., SEHRADER, L.E. and YOUNGS, U.L. 1975. Rapid Colorimetric Determination of Nitrate in Plant Tissue by Nitration of Salicylic acid. Comm. Soil Science and Plant Analysis 6(1):71-80.

CRAM, W.J., 1973. Internal Factors Regulating Nitrate and Chloride Influx in Plant Cells. J.of Exper.Bot., 24, 79:328-41

FERRARI, T.E., O.C.YODER, P.FILNER, 1973. Anaerobic nitrate production by plant cell and tissues: Evidences for two nitrate pools. Plant Physiol., 51: 423-431.

HERNANDO, V. and CADAHIA, C. 1973. El análisis de savia como índice de fertilización. Instituto de Edafología y Biología Vegetal. Madrid. pp 167.

HERNANDO, V., JIMENO, L. and CADAHIA, C. 1964. Estudio del estado de nutrición de tomateras mediante el análisis de la savia. Anales de Edafología y Agrobiología. XXIII, 1-2: 65-79.

MAAS, E.V. and G.J.HOFFMAN, 1977. Grop Salt Tolerance. -Current Assessment. 116-134. Journal of the Irrigation and Drainage Division.

SHANNER, D.L. and BOYER, J.S. 1976. Nitrate Reductase Activity in Maize Leaves II. Regulation by Nitrate Flux at Low Leaf Water Potential. Plant Physiol. 58:505-509.

SCHNABL, H. and RASCHKE, K. 1978. Availability of Chloride Affects the Balance between Potassium Chloride and Potassium Malate in Guard Cell of V.taba L. Plant.Physiol, 62: 84-87.

SUDER-MORAW, A. and BUCZEK, J. 1977. Nitrogen assimilation and nitrate reductase activity in tomato seedlings. II Effect of increasing calcium doses in the presence of high magnesium concentrations on nitrate reduction and protein content. Acta Societatis Botanicorum Poloniae. XLVI. 2:275-283.

TORRES, B.C. and BINGHAM, F.T. 1973. Salt Tolerance of Mexican Wheat: I.Effect of NO_3 and NaCl on Mineral Nutrition, Growth and Grain Production of Four Wheats. Soil Sci.Soc.Amer.Proc., 37:711-715.

ULRICH, A. and JOHNSON, C. 1959. II.Analytical Methods for use in plant analysis. Div.Agric.Sci. Univ.of Calif.Bullet., 766, 27:26-72.

RESUMÉ : INTERACTION DU CLORURE ET NITRATE EN TOMATES.

Des tomates de la varieté Marglobe ont été cultivées avec une solution noutritive dans une serre pour l'étude de l'effect du Cl^-. Cinq traitements avec du Cl^-: 0,8,16,24 et 32 $me.l^{-1}$ ont été combinés avec cinq concentrations differentes de NO_3^-: 6,12,18,24 et 30 $me.l^{-1}$. On trouve un effet coopératif du Cl^- et du NO_3^- en augmentant les deux concentrations, celle du Cl^- jusqu'à 24 $me.l^{-1}$ et celle du NO_3^- jusqu'à 18 $me.l^{-1}$. Ce qui indique qu'en augmentant le NO_3^- dans la solution l'effet toxique du Cl^- diminu. L'index qui s'ajuste le mieux aux rendements c'est celui de la relation N.org: N-NO_3^- (mg:mg) dont les valeurs doivent être proches à 1.

* * * * *