

AN EFFECT OF TEMPERATURE ON THE INHIBITION OF AMMONIUM ABSORPTION BY POTASSIUM IN EXCISED BARLEY ROOTS

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SUMMARY

The effect of K^+ on NH_4^+ absorption by excised barley roots was studied at different temperatures (3° and $25^\circ C$). With identical composition of the external solution, the inhibitory effect of K^+ appeared to be appreciably weaker at the low than at the high temperature. The bearing of this result on the interpretation of this interaction is briefly discussed.

1. INTRODUCTION

As shown in an earlier paper (BANGE *et al.* 1965), in binary mixtures of the monovalent cations K^+ , Na^+ , and NH_4^+ and in the absence of Ca^{2+} , the rate at which each of the components is absorbed by excised barley roots is reduced in a specific and limited way as compared with the uptake rates from single salt solutions. The characteristics of this interference were qualitatively identical for the three pairs Na^+-K^+ , $Na^+-NH_4^+$, and $K^+-NH_4^+$. At the time, we pointed out the difficulties associated with an interpretation of this behaviour in terms of a pattern of competitive and/or non-competitive inhibitions, and expressed our preference for an explanation based on competition not of the ions themselves but between the absorption processes with respect to some common requirement (BANGE 1962). We were the more impelled to do so by the observation made by TROMP (1962) that in excised wheat roots, inhibition of K^+ absorption by the presence of NH_4^+ ions does not obey the ratio of the ion concentrations in the external solution but rather is determined by the absolute level attained by NH_4^+ absorption in the root material concerned. In Tromp's experiments this level was influenced by manipulating the preceding nitrogen nutrition of the root material. In the present study we made use of the relative insensitivity of NH_4^+ absorption to low temperature (cf. MEIJER 1970, *fig. 18*) as compared with K^+ uptake, to study the interference under conditions of a constant ratio of external concentrations NH_4^+/K^+ but a varying proportion of the NH_4^+ and K^+ uptake levels.

2. MATERIAL AND METHODS

Excised barley roots were prepared as already described (BANGE & VAN IREN 1970).

The experiments on $NH_4^+-K^+$ interaction were performed in an apparatus for continuous flow described in detail by MEIJER (1970). At zero time the

roots were placed in the absorption vessels filled with about 100 ml of the inflow solution. The composition of these solutions was so chosen that the relation between amounts absorbed and time was as close to linearity as possible over the whole experimental period (*fig. 1. A and B*), thus approximating steady-state absorption. The unavoidable initial adjustment before a steady concentration of the outflow solution is reached, proved not to outlast the first absorption period of 85 minutes. At each temperature the inflow concentrations of NH_4^+ were adapted to the absorption rates expected in the absence and presence of K^+ , to insure equality of NH_4^+ concentrations in the absorption vessels during both treatments. Only in one case did the rate of NH_4^+ absorption in the absence of K^+ have to be corrected because this condition was not satisfied; for the correction we used the estimated K_m -value of NH_4^+ absorption in the absence of K^+ (± 0.008 mM; BANGE *et al.* 1965). No attempt was made to correct the slight difference in mean NH_4^+ and K^+ concentrations at the two temperatures, because its effect is to support the argumentation.

The pH lay in the slightly acid region; without rigorous control the lowest value was 5.3.

The experiments on Na^+ - Rb^+ interactions were done essentially according to HOOYMANS (1964).

NH_4^+ was estimated by the Nessler method. Precipitation of Ca^{2+} after the addition of alkali to the samples was prevented by adding Na_3 -citrate to a final concentration of 9 mM. The K^+ , Na^+ , and Rb^+ concentrations were determined by flame photometry.

3. RESULTS AND DISCUSSION

Despite equality of the ratio of K^+ and NH_4^+ concentrations at both temperatures, the depressing effect of K^+ on NH_4^+ absorption is much more pronounced at 25°C (66.0%; see *fig. 1C*) than it is at 3°C (35.0%) and is correlated with the rate of K^+ absorption at both temperatures. Thus the outcome is in complete agreement with the observations by Tromp referred to above and, like these, argues against the assumption that the interaction is due to some kind of mutual interference of the ions in their initial binding. Like a difference in nitrogen nutrition, a difference in temperature would not be expected to have a fundamental effect, in such a specific way, on the molecular structures in which such ion competitions are thought to occur. On the other hand, the present results support our view that the processes of K^+ , Na^+ , and NH_4^+ absorption, despite the high degree of specificity of the individual binding sites, share some part of the mechanism involved, for which they may compete when more than one ionic species is transported.

Recently it has been suggested (POOLE 1971) that this common factor is formed by the ions (anions or protons) transported simultaneously with the monovalent cations to maintain the electrical balance of the cell. However attractive this hypothesis may be, it seems to imply the existence of a stoichiometry in the interactions that is not always observed. In the experiment mentioned

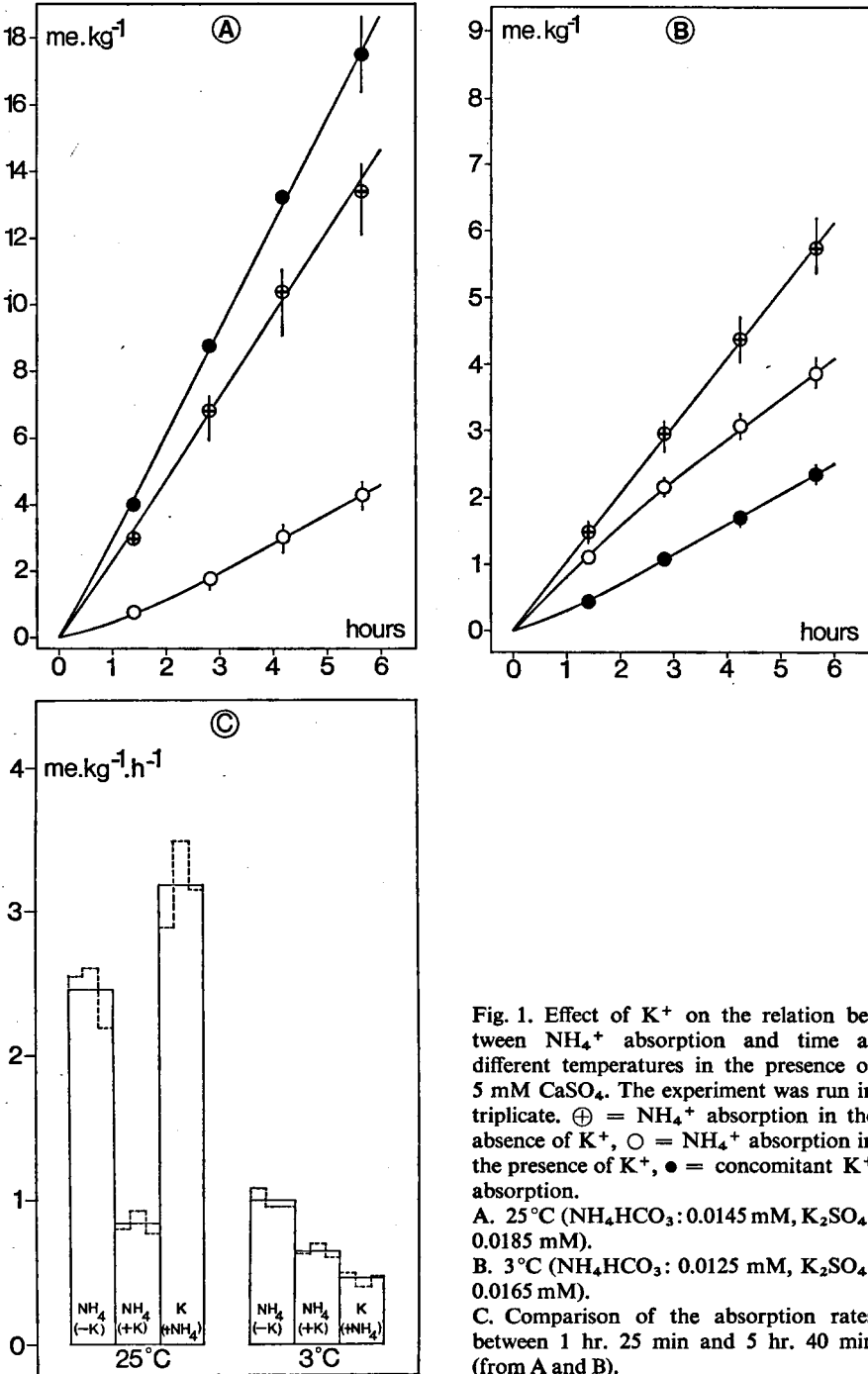


Fig. 1. Effect of K⁺ on the relation between NH₄⁺ absorption and time at different temperatures in the presence of 5 mM CaSO₄. The experiment was run in triplicate. \oplus = NH₄⁺ absorption in the absence of K⁺, \circ = NH₄⁺ absorption in the presence of K⁺, \bullet = concomitant K⁺ absorption.
 A. 25°C (NH₄HCO₃: 0.0145 mM, K₂SO₄: 0.0185 mM).
 B. 3°C (NH₄HCO₃: 0.0125 mM, K₂SO₄: 0.0165 mM).
 C. Comparison of the absorption rates between 1 hr. 25 min and 5 hr. 40 min (from A and B).

Table 1. Amounts of Na^+ and of Na^+ and Rb^+ absorbed between 3.5 and 6.5 hours from solutions of 0.2 mM NaHCO_3 and 0.2 mM $\text{NaHCO}_3 + 0.1$ mM Rb_2SO_4 , respectively, at 25°C and a pH slightly above 7. Mean of 7 experiments (\pm standard deviation).

Solution	Amounts absorbed (me.kg ⁻¹)			
	Na^+	Rb^+	(a)	(b)
NaHCO_3	13.20 (± 1.33)		-7.46 (± 1.49)	+3.87 (± 1.39)
$\text{NaHCO}_3 + \text{Rb}_2\text{SO}_4$	5.74 (± 0.94)	3.59 (± 0.64)		

(a) = reduction of Na^+ absorption in the presence of Rb^+

(b) = difference between reduction of Na^+ absorption in the presence of Rb^+ and concomitant Rb^+ absorption

in table 1, for instance, the addition of 0.1 mM Rb_2SO_4 to a 0.2 mM NaHCO_3 solution resulted in a decrease of the amount of Na^+ absorbed within 3 hours by 7.46 me.kg⁻¹, whereas concomitant Rb^+ absorption amounted to only 3.59 me.kg⁻¹. If the electrical balance of the cell were involved, there would be no need for the rate of Na^+ absorption to undergo a reduction amounting to about twice the rate of Rb^+ absorption.

Therefore, further specification of the common requirement involved will probably have to await more detailed information about the transport process at the molecular level.

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