KINETICS OF ROOT ABSORPTION FOR SOME NUTRITIONAL ELEMENTS AND APPLICATIONS IN PLANT NUTRITION

BY

Essam Mohamed Abd El-Moniem Mohamed

B.Sc. (Agric.) 1981,
Ain Shams University

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Title : Kinetics of Root Absorption for Some Nutritional Elements and Applications in Plant Nutrition.

Name : Essam Mohamed Abd El-Moniem Mohamed.

This thesis has been approved by:

Prof. Dr. M. K. Sadik

Prof. Dr. A. Elbadry

Prof. Dr. Talaat El Gala[illegible]

(Committee in charge)

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1. INTRODUCTION

Life on land is dependent on higher plants not only for energy and the primary carbon skeleton for essential compounds but also for the bulk of its mineral equirements.

Sustained growth of higher plant requires light, carbon dioxide, water, and mineral ions. One of the most fundamental problems of plant growth is how inorganic ions enter root cells, i.e., uptake process of ions.

Various investigators have followed the uptake by plant roots for short periods of time in order to study the uptake characteristics without the influence of growth or other interacting physiological processes.

The objective of present study was to characterize the dynamics of uptake process of ions and evaluation for its kinetic parameters. This has been

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performed through evaluation for uptake of both anions and cations using neutral salts. Also, a study for both ammoniacal and nitrate forms of nitrogen was involved whether they were singly or simultaneously present in the absorption media.

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2. REVIEW OF LITERATURE

Most studies concerning the mechanism of nutrient absorption have been conducted with excised roots (Epstein and Hagen, 1952; Fried and Noggle, 1958; Bange and Overstreet, 1960; Handley and Overstreet, 1961).

Excised roots usually function for several hours, at least with regard to ion absorption, as if they had never been removed from the shoot, Jackson and Stief (1965).

Hoagland and Broyer (1936) were the first to show the value of using exicsed roots that are low in salt content for studying nutrient absorption. Such roots were reported to accumulate salts in a short time as to easily measure the increase in ion content either chemically or by using radioisotope of a specific element.

Studies dealing with absorption of ions should deal with either anions or cations particularly for elements such as nitrogen which is known to be absorbed mainly as nitrate or ammonium.

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2.1. Anion Absorption:

The absorption of nitrate, representing various anions, was reported to be related to several parameters including time, pH, and the presence of various accompanied cations as well as different other anions along with concentration of the concerned ion in the absorption medium.

2.1.1. Time:

Minotti *et al.* (1969) performed studies on 14-day-old nitrogen-depleted wheat seedlings and found that with Ca, Mg, Na, and K salts, the initial rate of nitrate uptake measured at 3 hours was less than that after 6 hours. Subsequent experiments reveal that this lag during the first 2 to 3 hours is more pronounced and prolonged with KNO_3 than with $Ca(NO_3)_2$.

Jackson *et al.* (1972) showed the pattern of nitrate uptake over a 10-hour period from KNO_3 solution by 10-day-old nitrogen-depleted wheat seedlings. This pattern represents a slow rate of uptake during the first few hours followed by a more rapid rate

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which was relatively linear. Jackson et al. (1973) described the nitrate uptake to exhibit an adsorption shoulder during the first 20 minutes, again followed by a low uptake rate "called the lag phase" to then end with a maximal rate "called the accelerated phase". Similar results were found by Neyra and Hageman(1975) who reported that excised roots, obtained from seedlings grown in a nitrate-free medium (0.2 mM $CaSO_4$), showed a low initial rate of nitrate uptake (Lag phase) but gradually increased to a linear steady rate of accelerated phase. Such pattern of uptake as a function of time (lag followed by accelerated phase) was pointed out to be independent of accompanied cation and consequently exclusively dependent upon the nitrate ion.

Rao and Rains (1976) followed nitrate absorption by excised barley roots as a function of time from both 0.5 mM KNO_3 and 5 mM $CaSO_4$ solutions in the presence or absence of a 5 mM PO_4 buffer with pH 6, temperature being maintained at 30°C. At successive intervals of time, samples were taken from the external solution to assay its NO_3^- content as an expression

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for uptake by studied roots. The rate of NO_3^- uptake was found to be consistently higher during the 2nd and 3rd hours compared to that encountered during the 1st hour. The authors also found that absorption was lower from buffered solutions than from unbuffered ones, the pH of the latter solutions being dropped from initial value of 6 to a final value of 4.5 within 3hrs period.

2.1.2. pH:

Several investigations have been preformed to evaluate the response of anion uptake to medium pH.

Minotti et al. (1969) carried out 6 hours experiments using low N-seedlings and media having $Ca(NO_3)_2$ salt concentration of 0.4 meq/Liter, acidity of used solutions being periodically adjusted with NaOH or HCl to pH of 4.5, 5.5 or 6.5. Nitrate uptake was estimated to be 21.5, 25.4, and 25.6 meq. per culture for the three pH experimental sets, respectively. Correspondent uptake values obtained with media having a mixture of NH_4NO_3 and $CaSO_4$ were 16.6, 18.3, and 18.2 μeq. per culture, respectively. The authors

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concluded a little influence of acidity on nitrate from $Ca(NO_3)_2$ salt within a range of 6.5 and 5.5 although further decrease in pH to a value of 4.5 being relatively unfavourable.

Similar pattern was reported by Bassioni(1971) who found that nitrate uptake from $NaNO_3$ systems with pH 6.0 was always higher than from $NaNO_3$ media having pH of 4.0. Indicated response to pH may thus suggest that both H^+ and OH^- are involved in the absorption process. In fact nitrate uptake was repeatedly found to be decreased more markedly as the pH varied from a value of 6.0, higher or lower values being depressive.

Rao, Rains (1976) studied the effect of pH on anion absorption by barley roots subjected to nitrate solutions adjusted with HCl or KOH to initial pH values variable between 4 and 8.5, test solutions being mixtures of 0.5 mM KNO_3 and 5 mM $CaSO_4$. Results showed an increase in the NO_3^- absorption at lower pH values.

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2.1.3. Accompanied Cations:

Calcium:

An investigation was carried out by Minotti et al. (1968) on nitrogen-depleted wheat seedlings. An initial lag phase for nitrate uptake was enocuntered although found to be lessened, but not completely overcome, by presence of soluble Ca. On the other hand, maintenance of the more rapid subsequent rate of nitrate uptake, which developed after the initial lag phase, depended upon presence of soluble K. Finally a rapid phase was obtained and being enhanced when both Ca and K were present but curtailed by shoot excision or Ca deficiency.

The data suggest a beneficial influence of Ca on initial nitrate uptake by root tissue, while a continual K supply was apparently beneficial for nitrate transport. Later on, Minotti et al. (1969), showed that nitrate absorption was curtialed slightly at pH 4.5 compared to pH 5.5 or 6.5. The authors also showed influences of calcium on ammonium-induced depression for nitrate uptake. Adding an equivalent amount of $CaSO_4$ to NH_4NO_3 stimulated nitrate uptake

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