MUTUAL EFFECTS OF ION UPTAKE BY CARROT ROOT TISSUES

By

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Introduction

It has been recently shown by the author (1962) that D-aspartic acid, when supplied together with KNO_3 or NH_4Cl to carrot root disks, exerts a marked depressing effect on the rate of nitrate or ammonium nitrogen uptake. Differences in the rates of absorption of ammonium, nitrate and aspartate nitrogen led to the suggestion that the process of uptake might have involved association with a carrier at the surface and movement of the complex, followed by dissociation, in the interval vacuole of the cells. The aspartic acid used was neutralized with KOH to pH 7 before it was supplied to the culture media around the tissues. Therefore, it was obvious that the culture media was containing potassium and chloride ions in addition to aspartate and ammonium ions or containing potassium in addition to aspartate and nitrate. Consequently, it was desired to extend this work and study the uptake of potassium and chloride ions in presence of the different nitrogen sources.

Methods and Experiments

The plant material, the technique of the disk culture experiments, and the analytical methods were the same as in the earlier work described by El-Shishiny and Nosseir (1957). Potassium was determined by means of the flame photometer. Chloride was estimated by titration against standard silver nitrate using dichlorofluoresoein indicator as adopted by Stiles and Skelding (1940). Two experiments were done. Experiment I was designed to include K, aspartate, NH_4 and chloride ions simultaneously in the culture media. Therefore, duplicate samples of carrot root disks after being washed for 4 days in aerated distilled water, were transferred into culture vessels each containing 350 ml. of the following solutions : Distilled H_2O; 0.00125M D-aspartate; 0.005M D-aspartate; NH_4Cl; NH_4Cl + 0.00125M D-aspartate; NH_4Cl + 0.0025M D-aspartate; NH_4Cl + 0.005M D-aspartate. However, experiment II was designed to include K, aspartate and nitrate ions in the culture media and hence duplicate samples were cultured in the following culture media : Distilled water; KNO_3; KNO_3 + 0.00125M D-aspartate; KNO_3 + 0.0025M D-aspartate; KNO_3 + 0.005M D-aspartate. The concentration of NH_4Cl in experiment I and KNO_3 in experiment II was 0.005M. D-aspartic acid was neutralized with KOH to pH 7 before supplying it to the tissues.

Results and Discussion

As shown in Tables 1 and 2, ammonium, nitrate, aspartate, potassium and chloride ions, when present together in their respective culture solutions, were absorbed simultaneously at different rates by carrot root disks. Among the nitrogen sources, ammonium or nitrate ions were absorbed in preference to aspartate ions.

Also, Table 2 shows that the ratios of absorbed K to NO_3 were always higher than 1.0, suggesting that anions other than nitrate were absorbed to equalize the positive electrostatic charges of the cations absorbed in excess of nitrate. Alternatively, evidence was obtained that the excess absorption of cation over anion was compensated by the exosmosis of other ions from the tissues. These results show that carrot root tissue, like pine-apple roots, Sideris and Young (1950), absorbed more potassium than nitrate, suggesting differential rates for cations and anions. It is possible that the negative electrostatic charges of the root tissues might be responsible for greater attraction of K than of NO_3. Likewise, in Table 1, with K D-aspartate supplied to carrot tissues either singly or in combination with NH_4Cl, ratios of K to aspartate greater than 1.0 were obtained in all culture solutions except in that containing NH_4Cl + 0.00125M KD-aspartate. Here chloride ions were absorbed partly to balance the electrostatic charges of the cations absorbed in excess of aspartate and partly to balance the electrostatic charges of the ammonium ions absorbed.

Table I

Absorption of K D-aspartate and NH_4Cl by carrot root disks during 24 hours from different culture media

Culture media	absorbed[x]				% of initial concentration			
	NH_4-N	NH_2 acid-N	K.	Cl.	NH_4-N	NH_2 acid-N	K.	Cl.
Water control[xx]	-	-	-10.33	-	-	-	-	-
0.00125 M K D-aspartate	-	4.94	15.87	-	-	17.4	18	-
0.005 M K D-aspartate	-	19.20	20.30	-	-	16.2	6.1	-
0.005M NH_4Cl	51.71	-	-	94.80	43.9	-	-	30
0.005M NH_4Cl + 0.00125M K D-aspartate	39.55	9.80	7.25	90.05	33.1	33.4	8	28
0.005M NH_4Cl + 0.0025M K D-aspartate	38.50	12.17	24.30	92.55	32.1	20	14.3	30
0.005M NH_4Cl + 0.005M K D-aspartate	34.42	17.55	21.80	95.15	27.5	14.6	6.4	30

x Mgm./100 gm. fresh wt. of tissue

xx Exosmosis,

Table II

Absorption of K D-aspartate and K NO_3 by carrot root disks during 24 hours from different culture media

Culture media	absorbed[x]			% of initial concentration		
	NO_3-N	NH_2 acid-N	K	NO_3-N	NH_2 acid-N	K
Water control[xx]	-	-	-20.20	-	-	-
0.005M K NO_3	44.27	-	79.75	37	-	23.4
0.005M K NO_3 + 0.00125M K D-aspartate	38.17	0.60	114.05	51.5	2.1	25.6
0.005M K NO_3 + 0.0025M K D-aspartate	30.52	0.60	129.15	32.5	1.0	24.5
0.005M K NO_3 + 0.005M K D-aspartate	38.80 ?	0.60	135.00	32.8	0.5	19.4

x Mgm./100 gm. fresh wt. of tissue

xx Exosmosis.

Although the actual rate of intake of ions is greater with the higher concentration of the salt, actually the rate of absorption relative to the external concentration decreases with increase in concentration apart from the complications resulting from exosmosis of K or other ions in the culture solutions. It was stated by Stiles (1927) that when storage tissue is placed in distilled water, there is an exosmosis of ions which was found, in the present investigation, to include K ions. It would appear that there is still this tendency for exosmosis when the liquid surrounding the tissue is a K salt. It may be noted also that if this exosmosis is independent of the concentration of the external solution, then in a higher concentration of K, this tendency will reduce the absorption relative to the concentration less than in a weaker concentration. This might probably account for the relative absorption of K being higher from 0.0025M K D-aspartate than from 0.00125M concentration in presence of ammonium chloride. Similar results were arrived at by Stiles and Skelding (1940).

Again, as shown in Table 1, ammonium absorption as per cent of total supply decreases progressively with the increase of amino acid concentration in the various culture solutions. This might be due to the inhibiting effect of D-aspartate on ammonium uptake. As regards chloride uptake, the relative absorption was almost constant indicating more or less equal absolute rates of absorption from the different solutions.

On the other hand, Table 2 shows that the nitrate uptake as per cent of total supply decreases to almost one and the same level consequent to administration of various concentrations of D-aspartate. They might indicate that the inhibition of nitrate uptake by carrot root tissues was independent of the concentration of D-aspartate added.

It was of interest to find that D-aspartate has competed with nitrate or ammonium as a nitrogen source for carrot tissues. Thus antagonistic effects can be produced by combinations of substances radically different in their structure. This result has been repeatedly shown by the author in other publications and may substantiate the observations of Macht (1934) and Virtanen and Linkola (1946).

Summary

The uptake of different ions by carrot tissue was studied.

1. The ratios of absorbed K to NO_3 or K to aspartate or NH_4 to aspartate were always higher than 1.0. It is possible that the negative electrostatic charges of the root tissue might be responsible for greater attraction of K or NH_4 than of NO_3 or aspartate.
2. Chloride ions were absorbed partly to balance the electrostatic charges of the cations absorbed in excess of aspartate and partly to balance the electrostatic charges of the ammonium ion absorbed.
3. The rate of absorption relative to the external concentration decreased with increase in concentration except in certain cases.

References

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