LEVEL AND ORIGIN OF CARBOXYLATE IN BUCKWHEAT

by

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SUMMARY

Buckwheat was grown in media in which the supply of nitrate and potassium was varied. The relation between nitrate assimilation and the carboxylate content of the plant was examined.

In full supply of nitrate total carboxylate came from and was equivalent to the assimilated nitrate. Only when this nutrient was depleted, bicarbonate was absorbed and assimilated as the alternative source which caused carboxylate to accumulate in excess of the deficient level of organic nitrogen.

Shortage of potassium had no effect on the level of carboxylate because increased uptake of calcium and magnesium replaced the missing potassium.

INTRODUCTION

Consumption of inorganic anions and creation of anions of organic acids (malate, citrate, oxalate, etc.) via carboxylation reactions are coupled in order to maintain the cation-anion balance of the growing plant.

In nitrate nutrition the hydroxyl anion which would result from nitrate reduction alone fixes CO$_2$, and the resulting bicarbonate is converted into carboxylate to form a new companion anion for the metal cation taken up along with the consumed nitrate anion. Hence organic N, expressed as its equivalent of nitrate anion, is a direct measure of the equivalents of carboxylate produced by nitrate metabolism.

Reductive assimilation of sulphate seldom accounts for more than 6% of the carboxylate produced. With nitrate assimilation as the

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dominant source, the carboxylate produced will be stoichiometrically equivalent to the amount of organic N formed by the plant within the usual errors of measurement.

Cereals and grasses grown with nitrate nutrition lose some 50–60% of the carboxylate formed by subsequent decarboxylation in the roots and the release of bicarbonate to the medium. In these plants half of the CO₂ is fixed only to be released again. Plants of other species, such as young potato, tomato and sugar-beet, retain all the carboxylate formed, and when constantly supplied with nitrate containing nutrients their carboxylate content will be equivalent to their organic N content.

Breteler has made this clear for the young sugar-beet plant. As indicated by analysis for the cations, total N, Cl, total S and total P in the whole plant, including the roots, the plant had absorbed 25 meq K⁺ + Mg²⁺ + Ca²⁺ = C, and 25 meq of the anions NO⁻₃ + Cl⁻ + H₂PO⁻₄ + SO⁻₄ from a mixture of their salts supplied in solution. Within each group the proportion in which the ions were absorbed differed from that in the medium, but the sum of cations remained equivalent to the sum of anions absorbed from the nutrient salts.

Analysis for anions of which the ionic form had remained unchanged by metabolism (the residual tissue NO⁻₃ + Cl⁻ + total phosphate expressed as H₂PO⁻₄ + the residual tissue SO⁻₄ = A) indicated the presence of 7 meq/whole plant of the inorganic anions A. The total cation content (C) of 25 meq/whole plant had remained in balance with the 7 meq inorganic anions (A) and 18 meq carboxylate anions (C−A). The value (C−A) from plant analysis for inorganic ions, providing the numerical value of the total content of carboxylates, was equivalent to the 18 meq organic N/whole plant measured as the difference between total N and nitrate N.

Another source of carboxylates substitutes for nitrate metabolism when nitrate is removed from the medium and an excess of cations over nutrient anions begins to move into the plant along with bicarbonate anions derived from the dissociation of carbonic acid in the medium. The bicarbonate balanced by metal cations is converted into carboxylate in the roots, and translocated to the shoot as such. Since nitrate is metabolised in the leaves, the transition from growth with nitrate to nitrate-depleted growth involves a shift in the site of carboxylate formation from the shoot to the root.