

CT Jackson
Boston March 6th 1845

Profr. Asa Gray

My Dear Sir,

The question you put to me concerning the formation of oxalic acid which exists so abundantly in plants combined with Lime or Potash as oxalates of lime or lime oxalate of Potash is one of high scientific interest & as you observe a different one to answer. I fear you will not adopt my views but I am of opinion that the oxalic acid is formed from the organic acids of the soil absorbed by the roots of the plants. I am satisfied that a few years will alter essentially the opinions of Chemists & Botanists with regard to vegetable nutrition & that the organic acid salts will be found to play a most important part in vegetable nutrition. It seems to me strange that Liebig has overlooked so important a principle & that he should object to the Humic theory on the ground of the insolubility of the Humus of the soil in Water. The insolubility of the organic acids in the soil is owing generally to their combinations with certain bases such as Alumina, Iron & Manganese &c but these combinations are readily decomposed by Carbonate of Ammonia & Carbonates of the fixed Alkalies & the organic acids are rendered soluble little by little as required by plants. Hence the value of ammoniacal manures & of the Carb Ammonia of rain water. Also of the alkali of ashes & that discharged from felspar mica &c. The ammoniacal salt is known to be valuable exactly in the ratio of the organic acid required to be dissolved & has no ^{favorable} action when the organic acids are absent from the soil - & my expts in granular quartz composed with them in soil, Carb ammonia being used as the manure in both cases, no fruit was formed in the first while it was in the last case - Succinic acid contains 15 p ct of nitrogen Oxalic acid 6.69 p ct of Nitrogen. These of course act as

nitrogenized manures the moment they are liberated from their basis and are dissolved by potassic or ammoniacal solutions.

Apoecemic acid is very nearly of the same composition as pure animal & vegetable fibrine -

To keep near to the subject of the formation of the sugar & Oxalic acid of plants from Humine - let me give you the following recent formulas of Berzelius as calculated by Malaparte. Berz. *Chimie* - V 8 P. 13. 14 Woblen 2d. 1840 German.

$$\begin{aligned} 6 \text{ Atoms Humine} &= 12C \quad 12H \quad 6Ox \\ 6 \text{ Atoms of the Elements of Water} &= 12H \quad 6Ox \\ = 1 \text{ Atom of Cane Sugar} &= 12C. \quad 24H \quad 12Ox \end{aligned}$$

Grape Sugar may be formed as follows -

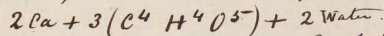
$$\begin{aligned} 6 \text{ At. Humine} &= 12C. \quad 12H. \quad 6Ox. \\ 8 \text{ At. Elements of Water} &= 16H. \quad 8Ox \\ = 1 \text{ Atom of Grape Sugar} &= 12C. \quad 28H \quad 14Ox \end{aligned}$$

Now Oxalic acid consists of $2C^4 \quad 2H^4 \quad 5O^5$ (Berzelius) and can be conceived to be formed by ~~the~~ a change in the composition of Humine as it is isomeric with Mucic acid it may be formed from that substance the following is their composition -

Oxalic acid	Ratio of At.	Mucic acid	Ratio of At.
Carbon 37.94 = 6		37.949 = 6	
Hydrogen 4.13 = 8		4.130 = 8	
Oxygen 57.93 = 7		57.921 = 7	

Is not as easy to conceive that Oxalic or mucic acid may be formed from Humine as it is to understand how Grape sugar changes into Cane sugar in the stalks of Indian corn as has been proved to be the case by experiments made

under my direction by Mr. Rich^d Sade Jr. The corn stalk before it is ripe contains only grape sugar while the ripe stalk contains Cane sugar identical with that of the cane? - There have been no crystals of oxalic acid found in the grasses by Mr. Bailey & the chemist officers & the with the formation of cane sugar - In the dicotyledonous or exogenous trees may not the exsuff of sugar after it has performed its function in fructification be ~~the~~ thrown off into the bark & cellular tissue in the form of Oxalic acid in combination with lime? Oxalate of lime is combined as follows according to the latest remarks of Berzelius -



supposing that a Humate or more probably a bicarbonate of lime was absorbed by plants & then acid digested by the plant was in part converted into sugar or other carbohydrates. Now nitrogenous compound of Carbon & Hydrogen the exsuff of acid & the lime might be carried off by excretion into the bark & old cellular tissue - I have no objection to the formation of these same matters from Humic gum or Mucic acid by a similar action - I know by my own remarks that Glycic acid = $(8C \ 10H. \ 5Ox)$ and Apoglycic acid $(18E \ 18H \ 8Ox)$

abound in all brown sugars and in the bone black after refining the brown sugar & that Glycic acid is very abundant in the bark of the sugar maple yellow & white Birch - I repeat then acids as having been formed by decomposition or re-arrangement of the elements of Mucic acid. I also consider Apoecemic & Croic acid as the great sources of supply of Nitrogen to plants. If I am mistaken in these views I shall be glad to be corrected but I think some new researches now making in ^{Germany} ~~Germany~~ ^{from Agnes Meyer} favor the results of my original estimates. I see that Dr. S. Schultze of Berlin has just published his researches in favour of a similar theory & I hope soon to see his book.

the only notice which has yet met my eye concerning it is one in
the New York ^{Amer} Agriculturalist edited by A.B. Allen Esq
do you know anything about it? See Gardens & Am.

I intend soon to try some experiments to ascertain if by
Chemical means I can convert the Humic acid obtained
by decomposition of sugar back into sugar again - No one has
tried this synthesis so far as I know.

Prof Asa Gray -
Cambridge
Mass.

Done of Chittenden with me to invite you to form a
Botanical Section for the Amer Association of Sci. & Nat. Hist.
I have written to J. Chandler of Mass to send home
letters of Chittenden & others. He sends as you request.

I shall be glad to have a list of subjects for remarks from
you & will take them up as opportunity offers. I would have
to give generalizations instead of particulars which I
hope nevertheless will suggest something to your mind that
may bring the question to a conclusion of again meeting
of sorts to some decision results -

Yours truly with high consideration
C.Y. Jackson



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