RELATIONSHIPS OF NITROGEN METABOLISM IN PLANTS*

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Introduction.—The nitrogen anabolism of green plants consists of the assimilation of inorganic nitrogen compounds into a system of complex organic substances. Of these complex substances, the amides and amino acids are comparatively simple in structure while the proteins and alkaloids are the most intricate. The proteins are the most important, since they form most of the living substance of the protoplasm. In the plant they are found in the colloidal, insoluble or soluble, amorphous or crystalline state.

Most of the nitrogen that the plant obtains from the soil is in the form of the nitrate ion. This fully oxidized form must be reduced to a lower valence form, such as ammonia, hydroxylamine or hyponitrous acid, before it can be utilized in synthesis. This reduction requires considerable energy which is made available by various respiratory systems. The ammonia, or the other reduced forms of nitrogen, when combined with the organic acid residues form the general class of compounds known as amides and amino acids. These amino acids are further combined to form the higher forms of nitrogen compounds, until the true protein molecule finally results.

It is believed that proteins are synthesized from the same amino acids that they yield on hydrolysis, thus the proteins essentially are amino acids condensed into chains. There are three classes of proteolytic enzymes found in the plant tissue, peptases, tryptases and the ereptases. The chemistry of these is well known but a modern trend of biological investigation is concerning the role of the less well known "vitazymes".

The "vitazymes" represent a group of vitamins which exert an enzymatic function in the tissue when combined with a colloidal protein carrier. Thus far, only two undoubted cases of "vitazymes" have

been described, vitamin B_1 and vitamin G, although vitamin C is suspected to act in similar manner. A possible role of vitamin G to nitrogen metabolism in the plant is briefly described below.

Experimental procedure.—A series of fifteen samples of young wheat plants grown in the field were analyzed for various nitrogen fractions, according to the procedures of the Committee on Methods of Chemical Analysis for the American Society of Plant Physiologists.(1) The distillation of ammonia was the modified method of Pucher, Vickery and Leavenworth.(2) The determinations of the vitamins were furnished by the research laboratory of the American Butter Co. in Kansas City. The nitrogen analyses were conducted in the Laboratory of Plant Physiology at the University of Illinois. The following nitrogen fractions were determined; ammonia, amide, amino acid, nitrate, residual, soluble, insoluble and total.

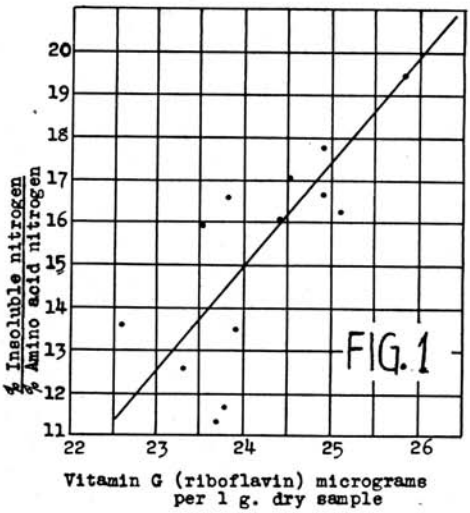

TABLE 1.—WHEAT SERIES

Plot No.	%Insoluble nitrogen	%Amino acid nitrogen	$\frac{\%Insol.N_2}{\%Am.ac.N_2}$	Vitamin G mgr/gm dry sample
2	2.97	0.22	13.50	23.9
3	3.00	0.18	16.68	24.9
4	3.01	0.24	12.54	23.3
5	3.12	0.16	19.50	25.8
6	3.06	0.18	17.00	24.5
7	3.00	0.21	14.29	24.6
9	2.94	0.25	11.75	23.8
10	2.87	0.18	15.95	23.5
11	2.82	0.17	16.60	23.8
12	2.90	0.18	16.10	24.4
13	3.42	0.21	16.28	25.1
14	3.02	0.17	17.78	24.9
15	3.32	0.16	20.75	20.7
16	2.58	0.19	13.59	22.6
17	2.84	0.25	11.35	23.7

Results.—The effect of different amounts of vitamin G on the ratio of insoluble nitrogen to amino acid is shown in table 1 and figure 1. It is seen that increasing amounts of vitamin G produce relatively increasing amounts of insoluble nitrogen per unit amount of amino acid nitrogen. This does not necessarily mean that vitamin G increases as insoluble nitrogen increases or as amino acid nitrogen decreases, since only the ratio of these forms of nitrogen is affected. It seems apparent that vitamin G is concerned with some physiological activity which enables the plant protoplasm to synthesize more complex forms of nitrogen containing compounds from the amino acid units.

Since in the chemical analysis of nitrogeneous tissue one cannot differentiate between the higher forms of insoluble nitrogen, it is evident that the exact significance of the enzymatic catalysis of vitamin G cannot be postulated. If the synthesis and hydrolysis of proteins can be postulated by the general equation, amino acids⇄polypeptids⇄proteins, riboflavin is concerned in some way in this process.

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1. Tottingham, W. E., Plant Physiol. 10,393-99, (1935).
2. Pucher G. W., Vickery H. B., Leavenworth C. S., Ind. Eng. Chem., Anal. Ed. 7,152-6, (1935).