PHOSPHORUS IN PLANTS

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NEARLY EVERY one is aware that phosphorus is one of the essential mineral elements in plants. Not so many, however, are aware of the different forms in which phosphorus occurs in plants, and the relationship of these forms to each other.

It is our intention here to review these forms and to discuss their importance and occurrence in plants, especially as indicated by our researches completed and in progress, and also to indicate the lines along which we are working to solve the functions of phosphorus in plants.

Since phosphorus is taken in through the root system, probably in an inorganic form, we cannot overlook this form. It is believed by many that unmodified plant tissue contains practically no inorganic phosphorus.

Recent work, including some carried out here, shows this to be erroneous, however. A few samples will show this:

	Total Phosphorus	Inorganic Phosphorus
Yellow corn	.347%	.012%
Mung bean	.530%	.024%
Alfalfa	.230%	.136%
Green onions	.337%	.189%

From these figures we see that inorganic phosphorus cannot be disregarded in studying the metabolism of this element. As to whether the varying amounts are incidental or determined by some physiological law we cannot say, although it seems this form is greatest in vegetative structures, making it seem that its function is chiefly that of a source of supply.

Turning now to the organic forms of phosphorus, we find that there are several sufficiently well characterized to merit consideration. First, we will discuss phytin compounds. The naturally occurring product is mainly a mixture of the calcium, magnesium and potassium salts of inosite hexaphosphate $C_6 H_6 O_6 (PO(OH)_2)_6$.

Phytins are a valuable food material since they supply calcium and phosphorus in readily assimilable form and also exert a mild laxative effect. It has been suggested that the chief value of bran foods is due to the presence of these compounds. Very little data is available at the present time regarding the presence of phytins in the vegetative stages of plants. Such data are being accumulated but at present we have only figures on storage organs, a few typical examples of which are the following:

	Total Phosphorus	Phytin
Corn	.319	.244
Wheat bran	1.41	1.24
Soybean	.53	.36

From these figures we see that phytin constitutes the bulk of the phosphorus of grains. It is possible that there is some connection between this form and the need for phosphorus by seedlings, since there are enzymes (phytases) in seeds which readily split out the phosphorus from the organic molecule.

The next form of importance is that known as lipoid or phosphatid phosphorus. This includes a large group of related compounds occurring in practically every portion of the plant, but present in largest amounts in the seeds. These include the lecithins and cerebrosides among others.

Until just recently there has not been any satisfactory method for estimating this fraction. However, Guerrant, from this station, has devised a workable method and we hope soon to make determinations on a large number of plant substances. A few figures we have available are as follows:

	Total Phosphorus	Lipoid Phosphorus
Soybean	.547	.097
Wheat	.427	.028
Darso 4 day seedlings	.228	.039
10 day seedlings	.230	.044

From these data we see that lipoid phosphorus is of considerable importance in seeds although our results so far have not indicated any particular relation between the fat content and lipoid phosphorus. In germinating plants there is a very definite increase in this fraction, indicating that perhaps it is this fat-like fraction that we are most concerned with in explaining metabolic changes in gorwing plants. We are beginning an extended study of lipoid phosphorus in both seeds and green plants. Due to the large amount present in seeds it is possible to isolate certain of these compounds. Along this line we have isolated the phosphatides from three grains and determined the iodine value of the fatty acids from them. This work is appearing in the Ohio Journal of Science, but we will give the iodine values here to show the wide divergence:

	Iodine value
Wheat	81.49
Corn	65.3
Soybean	92.48

From these figures we see that there are great differences among the grains in iodine value, and we intend fractionating such compounds secured from other seeds. There is a similar type of lipoids known as cerebrosides, and we hope to determine if there are any such fraction in plants. As yet, however, they have not been isolated from plants.

Still another of these fat-like compounds is the one isolated by Chibnall and Channon from the leaves of certain plants. They are known as glyceridephosphoric acid substances.

The work on this compound has just been started and little can be said about its functions.

The next type of compounds, nucleic acids, probably has been more studied than any other group, but only in a few plants, yeasts for example, in which they occur in great abundance. Apparently nothing is known about the distribution of these compounds in seeds or in green plants. Plant nucleic acids comprise the following general groups: Phosphoric acid, Pentose sugars, Purine bases, Pyrimidine bases.

We propose to try and devise a method for estimating this fraction in dried plant material. It must be borne in mind that this is a minor fraction

in amount and perhaps cannot be readily determined. Its significance must not be overlooked, however, since it is probably present in every living cell. Nucleo-proteins may also occur in plant cells. They are probably combinations of nucleic acids with various proteins.

Somewhat along this line is the group of proteins known as phosphoproteins, casein being an example. At present there is some question whether such forms occur in plants. Apparently none has been isolated and it would be only in seeds that we could hope to secure a large enough amount for study.

A somewhat similar compound is starch, which seems to contain approximately 0.09 per cent phosphorus. Of its significance in this compound we cannot say beyond the statement of the fact.

Finally, there are mono and dihexose phosphoric acids which may occur in plants, although the amount will probably be small. These are combinations of H_3PO_4 with such sugars as glucose or fructose.

In this brief discussion nothing has been said regarding the many reported functions of phosphorus in plants, although there is a long list of them. Rather, it is intended to direct your attention to the distribution of the phosphorus compounds in plants and the efforts we are making to determine these relations, a field heretofore scarcely touched upon.

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