CLIII.—*Note on the Localisation of Phosphates in the Sugar Cane.*

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SEVERAL investigators have shown that phosphoric acid, in the form of phosphates of calcium, iron, aluminium, &c., exists in the ashes of plants, but very little work appears to have been done in relation to the position of these salts in the plant.

Nessler (*Landw. Versuchs-Stat.*, 1873, 16, 185) showed that in the case of vines the nodes contained a larger quantity of phosphates than the internodes. He also pointed out that the nodes left a larger percentage of ash on ignition than the internodes. This, however, does not touch the question of the proportion of these compounds in the roots, stems, and leaves respectively.

In discussing the need of the sugar cane for phosphatic manures, it was suggested to me by Mr. Watts that it would be of interest to ascertain the amounts of these phosphates present in the root-portion, stem, and leaves of that plant. The question of the amount of phosphate necessary for the growth of the cane is one of great importance to the planter in the West Indies, in view of the present depressed condition of those islands. No doubt a certain quantity of phosphoric acid in one form or another is necessary for the growth of the plant, but the results of the experiments on the need of the sugar cane for artificial phosphates such as basic slag, calcium super-phosphates, &c., have shown that the application of large quantities of such substances to land on which sugar cane is to be grown is not only unnecessary, but in many cases actually detrimental to the yield of sugar per acre.

For the purpose of ascertaining the position of the phosphate in the plant, the sugar cane offers several advantages, chief of which is its freedom from branches, and also the ease with which the leaves fall from the stem. In fact, when a cane is cut, it is rarely necessary to strip the leaves from the stem, as they fall while the plant is growing, leaving only a few at the top.

For the purposes of experiment, three canes of the variety known as the "White Transparent," of good, vigorous growth and as free from disease as possible were selected. (It is practically impossible to obtain a cane entirely free from *all* disease, as every cane suffers more or less from the attacks of the fungus *Tricospharia sacchari*.) These canes were cut off at a distance of about one inch below the surface of the soil, the length of cane thus cut being about ten or eleven feet. On their arrival at the laboratory, they were carefully stripped of

whatever leaves were present, except those at the top. The top leaves were then very carefully taken off down to the growing point of the stem. The remaining portions of the canes were then cut into four equal parts, each section being about two and a half feet long. (A few root hairs were present on the bottom sections, but these were neglected.)

Each section and each set of leaves were then chopped into small pieces, carefully sampled by the method of quartering, and about 500 grams of each sample dried in the steam-oven for three days. A rapid preliminary drying is necessary in order to prevent fermentation.

For the further drying, each sample (of which there were fifteen) was then passed through a mill, again mixed by quartering, and about 15 grams of each put into a large weighing bottle and dried at a temperature not exceeding 110° until of constant weight.

The substances to be estimated were the phosphoric acid, calculated as phosphoric oxide, and the silica. For this purpose, a modification of Fluckiger's method was used (*Zeit. anal. Chem.*, 1889, 27, 637).

Ten grams of each sample were weighed accurately into a platinum dish and very gently ignited; to prevent any possible loss, a large sheet of white paper was placed under the tripod on which the dish rested, and any particles which fell were swept back into the dish. At this preliminary burning, it was not considered necessary to obtain the ash quite white, but great care was taken not to fuse it, as Raumer (*Zeit. anal. Chem.*, 1882, 20, 375) has shown that if too high a temperature be used for the ignition, a part of the orthophosphates present may be converted into pyrophosphates, and thus cause a deficiency of phosphoric oxide in the estimation.

The residual ash in each case was boiled for 10 minutes with 20 per cent. nitric acid, water added, and the whole filtered and well washed. The residue on the filter, together with the filter-paper (which had been previously tested for freedom from phosphates), was again ignited until a perfectly white ash was obtained. This process of extraction with nitric acid was repeated four times, the final residue being ignited and weighed and taken as silica after correcting for filter ash.

The combined nitric acid extraction liquors and the washings were united in each case and evaporated to about 20 c.c. In one or two cases the nitric acid extract was evaporated to dryness and hydrochloric acid added, but no silica separated.* Moreover, as the results were to be more comparative than absolute, the application of the same method throughout was sufficient.

* Preis (*Listy Chem.*, 13, 153) has shown that phosphoric oxide can be estimated in the presence of silica without error, provided the precipitate be washed with pure cold water.

The small volume of nitric acid solution was then nearly neutralised with ammonia and treated with 50 c.c. of ammonium molybdate in nitric acid and allowed to stand in a warm place for two days. As in all cases, the phosphomolybdate precipitate was of small amount, it was weighed directly in the usual way, and the phosphoric oxide taken to be 3·5 per cent. of this weight.

The results obtained are shown in the following tables, giving the actual percentages of phosphoric oxide and of silica obtained for each section and the leaves calculated on *dry* material.

	Leaves.	1st section.	2nd section.	3rd section.	4th section.
Cane I.					
P ₂ O ₅	0·194	0·147	0·045	0·019	0·105
SiO ₂	2·744	0·638	0·530	0·564	0·486
Ratio $\frac{100\text{P}_2\text{O}_5}{\text{SiO}_2}$	7·09	23·7	8·57	3·32	21·62
Cane II.					
P ₂ O ₅	0·251	0·163	0·053	0·050	0·093
SiO ₂	3·216	0·616	0·606	0·499	0·522
Ratio $\frac{100\text{P}_2\text{O}_5}{\text{SiO}_2}$	7·83	26·53	8·74	10·06	17·84
Cane III.					
P ₂ O ₅	0·259	0·201	0·043	0·038	0·089
SiO ₂	2·892	0·600	0·479	0·582	0·519
Ratio $\frac{100\text{P}_2\text{O}_5}{\text{SiO}_2}$	8·95	33·50	9·04	6·63	17·16

An examination of these figures will show the following points. (By the term "phosphoric acid" in these conclusions is to be understood phosphates of calcium, iron, aluminium, &c.)

(a) There is an immediate absorption of phosphoric acid by the roots of the sugar cane, as shown by the higher figures for the fourth section (that nearest the roots).

(b) A very rapid transference of phosphoric acid to the upper parts of the plant, as given by the small figures for the middle sections.

(c) A storage of phosphoric acid in the leaves and upper parts of the stem. (The leaves, as they fall from the cane, are left as manure for the ensuing crop, and doubtless form a good source of phosphatic manure for the plant.)

(d) As was only to be expected, the silica is highest in the leaves,

and the transference of this from the soil is carried out in a fairly regular manner.

No attempt was made to ascertain the actual form in which the phosphoric acid existed in the plant, although a short qualitative examination of the ash of various parts of the plant showed that calcium, iron, and aluminium were present in considerable quantities, and taking into account the work of Watson Smith on the ash of various Eucalyptus trees (Trans., 1880, 37, 416) it is probable that phosphates of these elements were the chief sources of the phosphoric acid present.