SOLUBILITY OF POTASSIUM IN CORN TISSUES[1]

V. H. MORRIS AND J. D. SAYRE

Introduction

In a recent paper (**6**) it was suggested that the composition of succulent plant tissues with respect to any constituent in true solution in the cell sap can be calculated from an analysis of sap expressed from the tissues. In applying this method of analysis to studies of the mineral nutrition of the corn plant, it was necessary to ascertain whether the potassium was entirely in solution in the cell sap. If this situation obtained, the method of analysis could be used to determine the total potassium content,—in some investigations a much simpler and more convenient procedure than the usual ash analysis involving drying and grinding the sample.

In investigating the potassium content of expressed corn sap, data were obtained which are believed to furnish an answer to the question as to whether potassium occurs in corn tissues entirely in expressible form or whether it may be partially fixed by association with cell constituents such as lignin. The data are presented in this paper.

The literature bearing on this subject is generally interpreted as leading to the conclusion that potassium occurs only in solution in the cell sap, and probably in inorganic form (**5, 1**). Recently, however, MCGEORGE (**4**) presented evidence suggesting the possibility of a system of base exchange in living plant tissues similar to that already demonstrated for soils, where a correlation has been found between such factors as lignin content of the organic matter and exchange capacity. INOZEMTZEV (**3**) has concluded from electrodialysis studies that the greater part of the potassium of plants exists in a complex nondialyzable form, and that the dialyzable potassium is probably in an organic form.

Material and methods

The material consisted of samples taken during a seasonal study of the distribution of potassium in the different parts of the corn plant. A single cross adapted to Wooster conditions was grown on a fairly uniform soil in a good state of fertility. On each sampling date several plants were brought into the laboratory and separated into the following parts: blade, sheath, upper stem (above ear), lower stem, tassel, husks, grain, and cob. Each part was finely cut in an electric foodchopper. The potassium content was calculated from an analysis of the sap expressed from portions of the ground tissue, as previously described (**6**). Samples of the ground tissues also were

[1] Investigations cooperative between the Division of Cereal Crops and Diseases, Bureau of Plant Industry and Department of Agronomy, Ohio Agricultural Experiment Station.

dried in a steam chamber and then prepared for analysis. Portions of a few of the samples also were extracted with hot water or with 5 per cent. alcohol, using 50 gm. of the green tissue in Soxhlet extractors and making the extract to a final volume of 500 ml.

Potassium was determined in the various kinds of samples after ignition with sulphuric acid, using 10-ml. aliquots of the expressed sap, 2.5 gm. of dried tissue, and 100 ml. of the extracts. The ashed samples were taken up in hot dilute HCl, filtered, and washed into 250-ml. volumetric flasks. The potassium was precipitated from 50-ml. aliquots by the chloroplatinate method (**2**), first removing the calcium as the oxalate. All samples were taken in duplicate and each value reported is the mean of the duplicates.

Results

It was desirable to determine first whether there was any potassium which was in an insoluble form or held by adsorption and that could be obtained by continued extraction but not by the sap expression method. The results obtained with a series of samples, reported in table I, do not indicate the

TABLE I

POTASSIUM CONTENT OF CORN TISSUE AS DETERMINED BY SAP EXPRESSION, EXTRACTION, AND ASH ANALYSIS OF DRIED TISSUE (PERCENTAGES ON GREEN WEIGHT BASIS)

DATE	TISSUE	SAP EXPRESSION	EXTRACTION		TOTAL IN DRIED TISSUE
			H_2O	5% ALCOHOL	
		%	%	%	%
June 30	Whole plant	0.23	0.25	0.25	0.27
July 7	Blade	0.35	0.36	0.30	0.34
July 14	Blade	0.43	0.45	0.35	0.46
	Stem	0.18	0.19	0.19	0.18
July 21	Blade	0.36	0.38	.....	0.40
	Sheath	0.26	0.26	.....	0.25
	Upper stem	0.18	0.13	.....	0.18
	Lower stem	0.13	0.11	.....	0.15
July 28	Blade	0.43	0.45	.....	0.49
	Lower stem	0.17	0.13	.....	0.17
	Ear	0.20	0.15	.....	0.20

presence of potassium which could be extracted but not expressed. Furthermore, as shown in the same table, comparison with the analysis of dried tissue shows that all of the potassium was obtained by both extraction and sap expression.

Further evidence that all the potassium is in solution in the cell sap and consequently can be determined in corn tissue by the sap expression method,

as well as by analysis of dried tissue, is afforded by the data from a series of 56 samples, the results of which are summarized in table II. Although the

TABLE II

POTASSIUM CONTENT OF CORN TISSUES AS DETERMINED BY SAP EXPRESSION AND ASH ANALYSIS OF DRIED TISSUE (PERCENTAGES ON GREEN WEIGHT BASIS)

TISSUE	NUMBER OF SAMPLES AVERAGED	SAP EXPRESSION	TOTAL IN DRIED TISSUE
		%	%
Blade	10	0.389	0.414
Sheath	7	0.319	0.317
Upper stem	7	0.176	0.189
Lower stem	9	0.184	0.178
Husks and silks	4	0.130	0.157
Grain	3	0.190	0.180
Cob	5	0.152	0.192
Hybrids (stem tissue)	11	0.165	0.185
Mean of all samples		0.226	0.240

mean of the 56 samples is slightly higher for total potassium in dried tissue, the difference (0.014) is not significant, since the standard deviation of the difference between the two methods is 0.029.

The only samples with differences large enough to approach significance were the last two samples of cobs, taken on August 18 and 25. The potassium contents by the sap expression method were 0.128 and 0.143 respectively, as compared with 0.204 and 0.247 for dried tissues. Whether these differences are due to discrepancies in technique, to mechanical difficulties in handling this kind of tissue, or actually represent the presence of potassium held in such a way that it could not be expressed, cannot be determined from these data. That it may well be due to the mechanical difficulty of expressing sap from cobs rather than to the high percentage of lignin in these tissues is indicated by the fact that the first three samples of cobs showed good agreement between the methods.

With the exception noted, the data indicate that the potassium in corn tissues is in solution in the cell sap and thus can be determined by analysis of expressed sap as well as by analysis of dried tissue. Since all the samples were first ignited with sulphuric acid, however, it is possible that some of the potassium might be in solution in organic form, or at least unionizable. Data obtained by the direct precipitation of the potassium in a cleared portion of the sap by sodium cobaltinitrite are presented in table III. The results by the different methods are in good agreement. From these it appears that all the potassium in corn tissues is in such a form that it can be directly precipitated by regents such as sodium cobaltinitrite, indicating that it is in true solution and ionizable.

TABLE III

POTASSIUM CONTENT OF CORN TISSUE DETERMINED BY DIRECT PRECIPITATION FROM EXPRESSED SAP AS COBALTINITRITE COMPARED WITH ASHED EXPRESSED SAP AND DRIED TISSUE ANALYSIS

Tissue	Total in dried tissue	Sap expression	
		Gravimetric	Colorimetric
	%	%	%
Blade	0.40	0.36	0.36
Sheath	0.25	0.25	0.26
Upper stem	0.18	0.18	0.19
Lower stem	0.12	0.13	0.14
Tassel	0.31	0.27	0.28

The assumption that a base exchange system exists in the plant implies, by analogy with the well known soil system, a tying up of bases, potassium for example, in insoluble form in absorption complex or chemical combination. From the data presented in this paper it may be concluded that with respect to potassium such a system does not obtain in the corn plant.

Summary

1. The potassium in corn tissue is entirely in solution in the cell sap and consequently can be determined by analysis of expressed sap as well as by extraction or dried tissue analysis.

2. With the possible exception of cob tissue, there is no evidence of the presence in corn tissues of any insoluble, fixed, or unionizable forms of potassium.

OHIO AGRICULTURAL EXPERIMENT STATION
WOOSTER, OHIO

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