A COMPARATIVE STUDY OF THE STEM EPIDERMIS OF CERTAIN SUGARCANE VARIETIES

By ERNST ARTSCHWAGER
Pathologist, Office of Sugar Plants, Bureau of Plant Industry, United States Department of Agriculture

INTRODUCTION

A casual examination of the anatomical structure of the stem epidermis in certain varieties of sugarcane revealed, among even the most uniform specimens, differences that seemed to merit more detailed study. Such differences, if established, would, it was hoped, supply diagnostic characters of value in classifying varieties and in determining relationships. Representative varieties of four species of sugarcane (Saccharum officinarum, S. sinense, S. barberi, and S. spontaneum) and of several species hybrids which were examined seemed to offer a sufficiently wide range of material within the genus to justify a preliminary study for the purpose of establishing whether these structures might be useful for the purpose.

The existence of certain varietal differences was already known to Wieler, who, in studying the structure of the sugarcane stem, examined the epidermis of several varieties and noted that in certain canes the siliceous epidermal cells were very abundant while in others they were much fewer in number. Wieler also described in detail the structure and development of these siliceous cells, but his conceptions were greatly modified in a later investigation by Frohmeyer. The observations of Wieler were extended by Mameli de Calvino in her study of the anatomy of Cuban canes. She noticed that varieties differed in the size of the different types of epidermal cells, the thickness of the walls, and the distribution of the stomata.

MATERIALS AND METHODS

The material for the present investigation was obtained from the fields of the Sugar Plant Experiment Station at Canal Point, Fla. Heinemann, in her study of the epidermis of corn, found great variation in the composition of the epidermis of the different internodes. In order to eliminate the effect of similar differences in sugarcane, special care was taken to select material that had reached the same stage of development. It was found that mature internodes which had reached their final length and were no longer covered by the

---

1 Received for publication June 28, 1930; issued December, 1930.
3 FROHNMEYER, M. DIE ENTSTEHUNG UND AUSBILDUNG DER KIESELZELLEN BEI DEN GRAMINEEN. 39 p., Illus. Stuttgart. 1914. (Bibliotheca Botanica, Heft 86.)
protecting leaf sheaths were best suited for a comparative study; and, since the middle portion of the internodes showed the greatest uniformity in the appearance and distribution of the various epidermal structures, material was always taken from this region. On the average 10 individual samples of each variety were tested, and it was noted that the variation in the different specimens of a single variety was but slight and did not exceed variations observed in different fields of a microscopic preparation. It should be understood, however, that the tests were based on one season’s crop and that practically all of the material came from the same field. It is therefore possible that under changed environmental conditions a somewhat different epidermal picture might be obtained; but because of the conservative nature of these structures such variation is not likely.

The epidermis was removed by the aid of Schulze's maceration fluid, but instead of using the prepared reagent as recommended by Grob, the writer adopted the following procedure, which gave most satisfactory results. A piece of epidermis with the adhering cortical and fibrous tissue was cut from the central part of an internode and placed in a test tube containing several crystals of potassium chlorate and a few cubic centimeters of concentrated nitric acid to which a few drops of water had been added. The mixture was carefully brought to a boil, and after a few seconds, as soon as the epidermis separated off in the form of a thin pellicle, the contents of the test tube were emptied into a Petri dish partly filled with water. The epidermis was then mounted on a slide and stained with chloroiodide of zinc. If the maceration process is interrupted at the right point, the epidermis stains a bright blue; but if the maceration is not successful, the stain will not take at all or the differentiation will not be satisfactory.

The number of short-cell groups in a square millimeter was determined by projecting the stained preparations on a screen of ample size. This was done in order to estimate their relative number as accurately as possible regardless of irregularities in distribution.

STRUCTURE OF THE EPIDERMIS

When the stem epidermis is removed in the manner described and is properly stained with chloroiodide of zinc, it appears under the microscope as made up of various kinds of cells, disposed, however, in a remarkably uniform pattern. Two distinct types of cells alternate with each other—elongated rectangular cells and short cells which occur singly or in pairs. (Pl. 1.)

The long cells, which constitute the greater part of the epidermal cells, form 4-sided prisms. They vary greatly in length, and their end walls, though commonly straight, are often pointed. The variation in width is less evident but becomes quite a factor when different varieties are compared with one another. The walls of the long cells have an undulated, strongly silicified middle lamella, which, in the stained preparation, appears as a pure-white wavy line. The thickening layers are also undulated but not uniformly at all points (fig. 1),

---

6 Grob, A. Beiträge zur Anatomie der Epidermis der Graminenblätter. 122 p., illus. Stuttgart 1896 (Bibliotheca Botanica, Heft 36.)
A.—Surface view of epidermis of Louisiana Purple stained with chloroiodide of zinc. X 1,000.
cc, Cork cell; ml, middle lamella of long cell; p, pit; lc, long cell; sc, silica cell

B.—Surface section of epidermis of Cayana. X 1,000. Notice the large number of pits in the walls of the long cells
and the degree of silicification is somewhat less. The outer wall of these cells is very thick, strongly silicified and suberized, and possesses a more or less strongly developed cuticle. The inner wall is much thinner than the outer one, stains a bright blue in the preparation, and is pierced by numerous pits. (Fig. 2.) Pits are also found in the lateral walls but are wanting in the outer one. Occasionally the lumen of the cells is filled with calcium oxalate in the form of crystal sand.

The short cells typically occur in pairs, one member of which stains with chloroiodide of zinc a golden yellow and is known as a cork cell; the other member of the pair appears a glistening white and is known as a silica cell. Often, instead of two short cells constituting a group, a larger number is found. (Fig. 3.) This increase may be brought about by the omission of a long cell, so that two short-cell groups join each other directly. Sometimes there are one or two extra cork cells present, and thus the group may be greatly enlarged. While an increase in the number of short cells in a group is the more common occurrence, it may happen that by the omission of the silica cell the short-cell group is reduced to one member. This situation is common in some varieties and constitutes, as will be seen later, a valuable diagnostic character.

The cork cells have relatively thin walls, suberized and silicified, and a large lumen which usually contains a solid deposit of some organic substance. Though variously shaped, in certain varieties they may be remarkably uniform, being usually broadly reniform with the greater dimension parallel to the long axis of the stem. Frequently they are square or rectangular, especially in varieties in which the silica cells are few in number or wanting. They may also be trapezoidal, triangular, or much elongated (pl. 1, A) with end walls square or pointed like thick-walled
hairs (fig. 4). These elongated cells are placed by Mameli de Calvino in a special class; they are, however, only an extreme type of cork cell. The walls usually stain with chloroiodide of zinc a golden yellow, while the lumen often contains silica. Sometimes the walls of these elongated cork cells are very thick and heavily infiltrated with silica so that they appear a glistening white in the preparation. The cork cell of a group in whatever form it occurs always lies vertically above the silica cell.

The silica cells are very uniform and usually rectangular with the long diameter parallel to the long axis of the stem. (Pl. 1, A, sc.) Occasionally they are broader than long, oval, or even round. In surface view they appear biscuitlike with slightly overhanging margins. The cells are practically solid, though in the center one commonly observes small air spaces often arranged in a row and containing some refractory material, the remains of the protoplast.

Comparatively few stomata are found in the epidermis of the stem, though there are varietal differences of which significant use can be made in classification. The structure of the stoma is normal except that its cells become strongly silicified, remaining pure white in the preparation.

THE EPIDERMIS OF CERTAIN VARIETIES

D-74

The variety D-74 stands more or less by itself because of the small size of its epidermal cells. (Fig. 5.) There are between 90 and 130 rows of long cells in a square millimeter, so that the average width of the cells varies from 7.7 µ to 11.1 µ. The number of short-cell groups in a square millimeter reaches 1,112 or more. Because of the large number of short cells, the long cells also are relatively short. However, the variation in length is so great that the determination of a mean value would have little significance. The short cells in section appear square, rectangular, or trapezoidal, and occasionally pointed. Sometimes they occur in pairs with one member of the pair a cork cell, the other a silica cell; sometimes the cork cell stands alone. The number of stomata varies, but as many as 14 have been counted in a microscopic field covered by a 16-mm. objective and a No. ×6 ocular, or an area of 2.4 sq. mm.

LOUISIANA PURPLE

In the Louisiana Purple variety also there is a preponderance of short cells (fig. 3), for as many as 928 were counted in a square millimeter, and, since they are comparatively large, their total area equals that of the long cells and may even exceed it. This fact becomes
evident at once if one views the epidermis under low magnification. There are, on an average, 100 rows of long cells in a square millimeter, so that the average cell width is about 10 μ. The long cells are, on the whole, comparatively short and their end walls are usually transverse. The cork cells are reniform, square, or pointed, but hairlike cork cells are rare. The short cells appear most often in pairs or double pairs with one member a cork cell, the other a silica cell. The number of stomata varies with the microscopic field. At most, however, there are only one or two stomata in a field.

The Yellow Caledonia variety is characterized by the partial or nearly complete absence of silica cells, a fact which makes it very easy to recognize, especially if one takes other characteristics into consideration. The pattern of the epidermis, viewed under low power, seems to vary. Sometimes the long cells are very regular in length and width; again the cells are variously shaped. Commonly, however, the long cells are rather narrow, there being 110 to 120 rows in a square millimeter, so that the width of the individual cell is on an average only 8.3 to 9 μ. The number of short-cell groups is about 800 in a square millimeter; the cells are trapezoidal, often pointed and hair-like. The cork cells are found singly or in groups, sometimes in pairs.
with one member a silica cell. In general, however, silica cells are few in number. With low power one notices longitudinally disposed rows of epidermal cells which possess thicker and more strongly silicified walls than the neighboring rows. The lumen of the cells often contains silica. Stomata are also quite rare, since never more than one is observed in a microscopic field.

P. O. J. 2714

The pattern of the epidermis of P. O. J. 2714 is very uniform and the cells themselves are regular. There are about 94 rows of long cells in a square millimeter, so that their average width is 10.6 μ. The number of short-cell groups is 816 to 916, which closely agrees with the previously described varieties. The long cells are apt to vary considerably in width. Since their walls are of medium thickness or less, these cells have a comparatively broad lumen and appear to be wider than they actually are. A comparatively large number of the long cells are filled with crystal sand. The short-cell groups contain in most cases only one type of cell, the cork cell. Because of the absence of the silica cell, the cork cell very often stands alone; occasionally the cork cells appear in twos and even threes. When solitary the cork cell is rectangular or trapezoidal; in association with other cork cells it is shorter and sometimes pointed. Stomata are rather common, although their distribution is erratic. One often counts as many as 10 or more in a microscopic field.

U. S. 759

U. S. 759, which is relatively thin stalked as compared with the varieties described above, possesses an epidermis made up of comparatively large cells. The epidermal pattern is remarkably uniform. There are 72 rows of long cells in a square millimeter, so that their average width is 13.6 μ. The group of short cells is also greatly reduced in number, there being only 428 to 440 in a square millimeter as contrasted with 1,000 or more in D-74. The long cells are very uniform and possess transverse end walls. The calcium oxalate cells occur singly or in groups and are readily recognized by their glistening contents. The composition of the short-cell groups is similar to that in the preceding variety. The short cells appear in pairs (fig. 6) or the silica cell is wanting. The distribution of the stomata is erratic. Sometimes two are counted in a microscopic field; sometimes not even one.

P. O. J. 36

The P. O. J. seedlings that have Chunnee as the male parent are characterized by an epidermis in which the elongated or pointed cork cells are conspicuous and in which the epidermal pattern is more or less irregular.
The epidermis of P. O. J. 36 is quite irregular. The long cells appear narrow, more or less curved, and the end walls are often pointed. There are 74 rows of long cells in a square millimeter, their average width being 13.54 μ. The number of short-cell groups varies greatly and is difficult to estimate. The cork cells are quite irregular, often pointed and hairlike. The distribution of stomata is as irregular as in the other varieties. There are on an average 5 in a microscopic field, though as many as 12 have been counted.

P. O. J. 213

The epidermis of P. O. J. 213 is commonly very irregular and contains many elongated or hairlike cork cells. (Fig. 4.) The long cells have oblique or transverse end walls and are often of considerable length. They appear quite narrow, but actual counts show that there are on an average 89 rows of long cells in a square millimeter, so that their average width is 11.25 μ. The short cells appear in groups of 10 or more, one member of the group a silica cell. While the silica cells have the normal rectangular form characteristic of all varieties, the cork cells are variously shaped; and, since many of them are considerably elongated, the entire area they cover is at least equal to that covered by the ordinary epidermal or long cells. The actual number of short-cell groups in a square millimeter is approximately 372. Stomata are rare, usually less than one in a microscopic field.

P. O. J. 234

Compared to the variety just described, which it resembles greatly, P. O. J. 234 possesses a much more regular epidermis. The long cells are uniform and commonly have rectangular cross walls. There are 80 rows in a square millimeter, so that the average width of the cell
The number of short-cell groups is greater than in the former variety, there being between 376 and 484 in a square millimeter. The groups of short cells are made up of both cork cells and silica cells. The cork cells, though of somewhat variable form, are much less conspicuous than those of P. O. J. 213. The cells are more or less rectangular, though there is a tendency for them to be triangular and even hairlike. Stomata, however, are more abundant, there being on an average four in a microscopic field.

KASSOER

The epidermal pattern in the Kassoer variety also is quite regular. (Fig. 7.) The long cells are relatively short, but sometimes much elongated; their end walls are typically rectangular but occasionally pointed. There are on an average 75 rows of long cells in a square millimeter, so that the average width of the long cells is 3.3 μ. The short cells are in groups of two or more, but the silica cell is occasionally wanting, so that the cork cells are solitary. Occasionally a silica cell stands alone between the long epidermal cells. The number of short-cell groups in a square millimeter varies from 364 to 480. The shape of the cork cell is commonly broadly reniform; occasionally the cells are rectangular, more often pointed and hairlike. The distribution of stomata is erratic, there being on an average one or two in a microscopic field.

U. S. 663

The epidermis of variety U. S. 663 appears very regular. (Fig. 8.) The long cells are uniform and have straight, sometimes pointed end
walls. There are 80 rows of long cells in a square millimeter, so that their average width is 12.5 \( \mu \). The number of short-cell groups varies, there being from 480 to 540 in a square millimeter. The cork cells are reniform, sometimes rectangular, sometimes pointed, and occasionally hairlike. The short cells occur in pairs; often, however, the silica cell is wanting. There is commonly one but sometimes as many as five stomata in a microscopic field.

**U. S. 833**

The epidermis of U. S. 833 resembles that of U. S. 663, except that the long cells are relatively short. The pattern is very uniform. There are 75 rows of long cells in a square millimeter, so that their average width is 13.3 \( \mu \). The number of short-cell groups is very uniform, there being on an average 656 in a square millimeter. The cork cells are usually reniform, occasionally square or pointed, sometimes hairlike. The short cells occur in pairs with one member a cork cell, the other a silica cell. Stomata are numerous, with as many as 15 in a microscopic field.

**CAYANA**

The pattern of Cayana is fairly uniform. (Fig. 2.) The long cells appear comparatively broad and short, but often they are quite elongated. Their end walls are usually rectangular. There are 75 rows of long cells in a square millimeter, so that their average width is 13.6 \( \mu \). The number of short-cell groups averages 644 in a square millimeter. The cork cells are uniform, sometimes rectangular, sometimes pointed. They are usually joined to silica cells, but the latter may occasionally be wanting so that the cork cells stand alone. Stomata are rare, but occasionally four to six are counted in a microscopic field.
CHUNNEE

The epidermis of the Chunnee variety is composed of small cells with an average diameter of 7.6 μ. It has, however, only 504 groups of small cells in a square millimeter. It differs in this respect from variety D-74, which, besides having narrow epidermal cells, has also a large number (over 1,000) of groups of small cells. The pattern of the epidermis is very uniform, with silica and cork cells in typical pairs. Stomata are infrequent.

SACCHARUM SPONTANEUM

Although Saccharum spontaneum, like Chunnee, is a thin and fibrous cane, the epidermis is made up of large cells (fig. 9, A) with an average width of 12.5 μ. The number of short-cell groups is small, rarely exceeding 400 square millimeters. Silica cells are usually wanting, but stomata (fig. 9, B) are comparatively abundant.

DISCUSSION

The variations in epidermal structure, as shown in Table 1, fall into two classes—qualitative and quantitative. Qualitative differences consist in the absence of silica cells and of elongated or hair-like cork cells. In the last analysis, however, these also are quantitative variations, since there is rarely a complete absence of either type; but even the partial absence of silica cells presents a picture so striking that some varieties could be recognized by this character alone. This is true, to a lesser degree, of the elongated or pointed cork cells also. There are varieties in which they are practically absent, while in others, especially P. O. J. 213 and 36, they are so abundant that one would experience little difficulty in identifying the variety. Among quantitative variations are the width and length of the long epidermal cells, the number of short-cell groups in a unit area, and the distribution of the stomata.

The variation in the width of the epidermal cells often aids in the separation of varieties when other diagnostic characters fail. It is important, however, to estimate correctly the average width of the cells. This may be difficult in varieties which have an irregular epidermis, as for example, P. O. J. 36. One can calculate the average width of the long cells by counting the number of rows in the microscopic field and dividing the diameter of the field by that number; more accurate counts, however, are obtained by projecting the stained preparation on a white screen. The thickness of the walls of the epidermal cells is more or less uniform. As a rule, a narrow-celled epidermis, as for example in D-74, has comparatively thin walls. The type of undulation of the walls also varies in the different varieties, as can easily be seen in the accompanying figures.

A certain ratio exists between long-cell and short-cell areas which can be calculated by determining the number of groups of short cells
in a unit area. It must be borne in mind, however, that in varieties with single-cell groups, that is, where the silica cells are wanting, the area of short cells will be less, while in varieties with a large number of elongated or hairlike cork cells this area will be greater than the calculated value.

The distribution of stomata, although erratic, offers a valuable diagnostic character. P. O. J. 213 and P. O. J. 234 are much alike in

![Figure 9](image)

**Figure 9.**—Epidermis of *Saccharum spontaneum*: A, Showing solitary cork cells. X 500. B, Showing a stoma and pitting of the cork cells. X 1,000

the appearance of the epidermis; the former, however, has only one or two stomata per microscopic field, while the latter has from four to six.

In order to trace group relationships and analyze the parental influence in the various crosses, it would be necessary to examine the epidermis of a large number of canes, especially the early parent types. It would be of interest to trace the development of the elongated or hairlike cork cells back to the ancestral forms. All P. O. J. canes examined, with the exception of P. O. J. 2714, possess this type of cell. The male parent of these varieties is Chunnee and the female parents are Louisiana Purple and Gestrept Preanger, respectively. Neither
of the parents possesses the elongated cork cells, and it might be inferred that this character belongs to some earlier ancestor. In Kassoer and the U. S. seedlings these pointed cork cells are practically absent. At the same time these varieties exhibit in a greater or less degree a suppression of the silica cells, causing many of the short-cell groups to be composed of solitary cork cells. These two characters—that is, absence of elongated cork cells and suppression of the silica cells—are most significant in the epidermis of *Saccharum spontaneum*, a distant male ancestor of these varieties. The distribution of stomata is another character that defies a ready analysis. There appears to be no correlation between the number of stomata and the size of the epidermal cells. In D-74, which is the smallest-celled variety studied, the number of stomata is comparatively large, while in Chunnee, which also possesses small cells, stomata are rare.

**Table 1.—Epidermal characters useful in separating cane varieties**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Average width of cells ( \mu )</th>
<th>Number of short-cell groups per square millimeter</th>
<th>Pointed elongated cork cells</th>
<th>Solitary cork cells</th>
<th>Number of stomata per microscopic field</th>
<th><em>a</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Louisiana Purple</td>
<td>10.0</td>
<td>±928</td>
<td>Absent</td>
<td>Scarcely</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>D-74</td>
<td>7.7</td>
<td>±1,112</td>
<td>do</td>
<td>Abundant</td>
<td>14</td>
<td>1-2</td>
</tr>
<tr>
<td>Yellow Caledonia</td>
<td>9.1</td>
<td>896-780</td>
<td>Present</td>
<td>do</td>
<td>1 or less</td>
<td></td>
</tr>
<tr>
<td>P. O. J.:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2714</td>
<td>10.5</td>
<td>816-916</td>
<td>Absent</td>
<td>do</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>13.5</td>
<td>±528</td>
<td>Present</td>
<td>Absent</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>213</td>
<td>11.25</td>
<td>±372</td>
<td>do</td>
<td>do</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>294</td>
<td>12.5</td>
<td>376-484</td>
<td>do</td>
<td>do</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Kassoer</td>
<td>13.3</td>
<td>364-480</td>
<td>Scarce</td>
<td>Scarce</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>U. S.:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><em>a</em></td>
</tr>
<tr>
<td>663</td>
<td>12.5</td>
<td>480-540</td>
<td>Absent</td>
<td>Abundant</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>833</td>
<td>13.3</td>
<td>±856</td>
<td>do</td>
<td>Absent</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>759</td>
<td>13.6</td>
<td>428-440</td>
<td>do</td>
<td>Abundant in places</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cayana</td>
<td>13.6</td>
<td>±644</td>
<td>do</td>
<td>Scarce</td>
<td>4-6</td>
<td></td>
</tr>
<tr>
<td>Saccharum spontaneum</td>
<td>12.5</td>
<td>±600</td>
<td>do</td>
<td>Abundant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chunnee</td>
<td>7.6</td>
<td>±504</td>
<td>Absent</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*a* Covered by a 16-mm. objective and a No. X6 ocular, or an area of 2.4 sq. mm.

The following key affords, in a restricted sense, a means of identifying sugarcane varieties and hybrids of *Saccharum officinarum* and of tracing group relationships. It is as yet limited in its scope because of the restricted number of varieties studied, but its field of usefulness may be increased by extending the investigation to all important varieties.

**KEY**

1. Epidermis small-celled. Number of short-cell groups exceeding 20 per microscopic field (2-mm. oil-immersion objective and No. 6 eyepiece covering an area of 0.025 sq. mm.). Average width of elongated epidermal cells mostly below 10 \( \mu \).
   1. Elongated pointed cork cells numerous. **Yellow Caledonia.**
   2. Elongated cork cells wanting or few in number.
      A. Cork cells often solitary. **P. O. J. 2714.**
      B. Short-cell groups usually in pairs or double pairs with one member of the pair a cork cell, the other a silica cell.
         a. Stomata numerous. **D-74.**
         b. Stomata scarce. **Louisiana Purple.**
II. Epidermis large celled. Number of short-cell groups 16 or less per microscopic field.

1. Elongated cork cells more or less conspicuous.
   A. Stomata rare.  
   B. Stomata numerous.
   a. Elongated cork cells abundant; 5–12 stomata per field (16-mm. objective, No. 6 eyepiece).  
   b. Elongated cork cells less conspicuous; stomata 4–6 per field.

2. Elongated cork cells few in number or wanting.
   A. Stomata scarce, rarely more than one per microscopic field.
   a. Solitary cork cells numerous.
   b. Solitary cork cells less evident.
   (1) Distribution regular.  
   (2) Distribution erratic.
   B. Stomata numerous.

SUMMARY

The stem epidermis of sugarcane can be removed for study by the use of potassium chlorate and nitric acid, and its component structures differentiated by staining with chloroiodide of zinc.

The epidermis is composed of ordinary or "long" cells and of "short" cells. The latter occur commonly in pairs with one member a cork cell, the other a silica cell. The silica cell is biscuit-shaped, varies little in size and form, and may be wanting. The cork cell is reniform, rectangular, trapezoidal, or elongated like a hair. The occurrence of elongated cork cells is more or less restricted to certain varieties. Stomata are very rare in some varieties, less so in others, and always erratic in distribution.

Since the structure of the epidermis is characteristic of the variety and since its composition appears to be little influenced by environmental factors, it is useful in identifying varieties.