GANZHENKO O.M., CSc
Institute of Bioenergy Crops and Sugar Beet

METHODOLOGY FOR DETERMINING LEAF AREA OF SUGAR SORGHUM

The methodology to determine the leaf area of sweet sorghum, by scanning the leaf blade on a flatbed scanner and subsequent treatment of the obtained image files using special software. Determined the conversion coefficients for determining leaf area of different varieties and hybrids of sugar sorghum by calculation method.
    Key words: *sugar sorghum, leaf, leaf area, flatbed scanner*

Introduction. There are several methods determining the area surface of plant leaf [1-12]. The most prevalent method is carving method. This method does not provide high accuracy, because it is based on comparison mass of leaf and carving known area from this sheet. The uneven distribution of mass along the surface of the sheet , thus, is not taken into account.

Equally famous is the calculation method which is based on the correlation between area of leaf and its dimensions (length, width) and it uses the conversion coefficient. However, for high precision calculations have to determine the conversion factor not only for each crop, but also for some of its varieties or hybrids. For that, you must use direct methods for determination of leaf surface area.

There are methods for the direct determination the area surface of plant leaf, which consist in drawing the contours of the leaf on graph paper or overlay grids (mosaic) on the leaf, followed by calculation of the area. [6] In this case, the leaf area determined directly, and thus accuracy will be higher, but it is much more complicated and the process of determining the area is slowing down.

The use of special mechanical or electronic devices for determining the area surface of plant leaf (planimeters) allows speed up the calculation of the area and provides a sufficiently high accuracy, but the high cost planimeter and the possibility of subjective errors makes using planimeter inappropriate.

Analysis of recent research and publications. Researching of methods for determination of leaf surface area of different crops were engaged such scientists and researchers, as G.Z. Berson (tomatoes) [1], N.G. Hizbullin (beet seed) [2] V.V. Nikolaienko and N.I. Fedoryak (strawberry) [4, 8] L. Williams and F. Montero (grapes) [10, 11], F. Stikle (sorghum) [12] and others. However, those methods do not allow to promptly with precision determine the area of leaf surface.

Therefore, the *purpose* of the present research is developing of highly accurate method for determining the area of leaf surface. This method will clarify the conversion factor for determining the leaf surface area of modern varieties and hybrids of sugar sorghum.

Materials and methods researches.

The researches of area of leaf surface of sugar sorghum modern varieties and hybrids were conducted during the 2010-2013. The square was determined by scanning at least 1,000 leafs of each hybrids. Analysis of scans were performed by the program AreaS 2.1, which was designed by A.M.Permyakov from Samara's DSHA (www.ssaa.ru). The software and the conditions of its use can be found at http://www.ssaa.ru/index.php?id=proekt&sn=05.

Dependence of leaf surface area from size of the leaf were determined using correlation and regression analyzes.
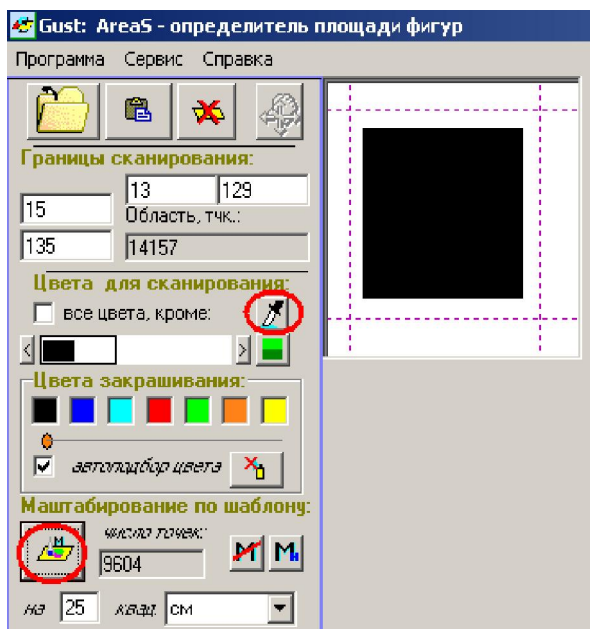
Results. For the determination of leaf surface area of sugar sorghum by the proposed method should select 10 plants in a row, which is at a distance of at least 3 meters from the edge of the area. Density between plants should be specific for the variant of the experiment. The selected plants are cut off at the level of the surface of the field and determined the biometric parameters: length and mass of plant; diameter of stem; number of leaves and their dimensions (length and width).

Then the leaves are cut into pieces of 25 cm length. Parts of a leaf are put into a transparent envelope (clerical file) so the individual parts do not touch each other. After that the files with parts

of leaf are scanned by a flatbed scanner. Scaner resolution must be the same for all scans. If scanning process will be done in a few hours or the next day, files with leaves are recommended to put under the press (plate of rigid material of at least 35x25 cm, which set the load weight 5 ... 10 kg on).

Determination of leaf surface will be carried out by comparing with a known area (template). For creation of template image is necessary to scan the figure with known area. To do this, must cut the square (template) with size, such as 5x5 cm on black paper. Accuracy determination of leaf surface will depend of the accuracy of the sizes of the template. Keep in mind that the scaner resolution during scanning files with leaves and template must be the same.

For determination leaf area of sugar sorghum using scanned images by software AreaS 2.1, which at first needs to be calibrated. For this in window AreaS click "View picture" (Открыть рисунок) and open the file with the template image. Specifing the scan limits so that the black square of template will be inside the perimeter of the dotted lines (Fig. 1). In the "Color to scan" (Цвет для сканирования) with "pipette" select black color because our object is black. In the "Zoom template" (Масштабирование по шаблону) click "Define the scale" (Определение масштаба). Then the program determines the number of pixels (dots) inside the template. Specify area of template and units (25 cm^2). To avoid incorrect determination of leaf surface, calibration should be done each time you start the software AreaS.

Then begin to define the area of the leaf surface. To do this, open the file with the image of leaf and set limits scanning so that all parts of the leaf were inside the perimeter of the dotted lines (Fig. 2).

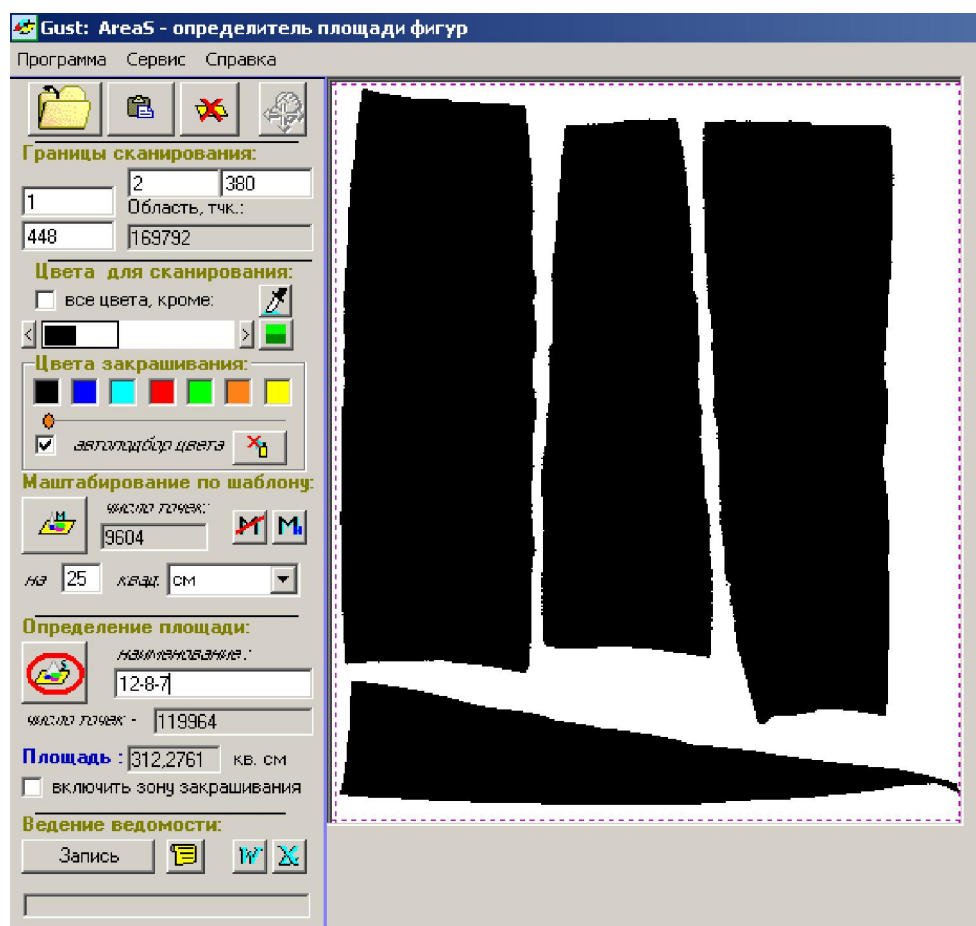Fig. 1. Software AreaS is calibrating.

Fig. 2 Determination of leaf surface using AreaS

In the "Determination Square" (Определение площади) you should push button of the same name. After this the procedure for calculating the area will be started. Then in the "Area" (Площадь) appears numeric value of leaf surface in appropriate units (cm^2).

Leaf surface of sugar sorghum determined as the sum of all its functional leaves.

According to this method during 2010-2013 conducted research on the determination of leaf surface of plants sugar sorghum hybrids Medoviy, Favorit and grade Silosniy 42 which entered into the State Register of Plant Varieties and perspective hybrids Buyvil, Bison, Mamont and Nectarniy, bred by SGI NSCSS. Having used methods of correlation and regression analysis it was found linear relationships between leaf size and leaf surface area for each of the studied hybrids of sugar sorghum.

The close correlation (r = 0,976...0,995) between leaf surface area and multiplication length and width of leaf was established (Table 1). Correlation of such force indicates the possibility of accurate determination of leaf surface through multiplication length and width of the sheet, with no need to pluck a leaf.

So leaf area of sugar sorghum can be determined by the formula:

$$S = k \cdot L \cdot B,$$

(1)

S – surface area of the leaf, cm^2;

k – dimensionless empirical coefficient reflecting the ratio between leaf area and multiplication of its length to width;

L and B – respectively leaf length and width, cm.

Table 1

The results of correlation and regression analyzes

Varieties and hybrids	Correlation coefficient, r	Standard error, S_r	Essentiality test, t_r ($t_{0,05}$=1,98)	Regression coefficient, k	Standard error, S_k	Essentiality test, t_k ($t_{0,05}$=1,98)
Medoviy	0,976	0,022	44,6	0,736	0,016	45,3
Favorit	0,989	0,015	65,5	0,753	0,012	65,0
Silosne 42	0,982	0,019	52,1	0,749	0,015	49,7
Bizon	0,981	0,020	50,0	0,751	0,015	50,8
Zubr	0,995	0,010	97,3	0,755	0,008	98,4
Mamont	0,990	0,015	68,2	0,760	0,012	65,6
Nektarniy	0,986	0,017	57,9	0,738	0,013	55,7

The coefficient k for different hybrids of sugar sorghum determined by empirical method using regression analysis of experimental data. Results of the analysis (Table. 1) indicate that coefficient k varies from 0.736 (hybrid Medoviy) to 0.760 (hybrid Mammoth). The standard error does not exceed S_k = 0,016, and materiality criterion within t_k = 45,3 ... 96,5, which is much higher than tabulated values $t_{0,05}$ = 1,98. So the estimated regression coefficients k for all investigated hybrids are correct.

Thus, the surface area of leaf of sugar sorghum can be determined using the formulas given in Table 2.

Table 2

Formulas for calculation of leaf surface

Sort / hybrid of sorghum sugar	Formulas
Medoviy	$S = 0,736 \cdot L \cdot B$
Favorit	$S = 0,753 \cdot L \cdot B$
Silosne 42	$S = 0,749 \cdot L \cdot B$
Bizon	$S = 0,751 \cdot L \cdot B$
Zubr	$S = 0,755 \cdot L \cdot B$
Mamont	$S = 0,760 \cdot L \cdot B$
Nektarniy	$S = 0,738 \cdot L \cdot B$

During the years 2012-2013 were audited precision determination of leaf surface by different methods. For control adopted values of the area, obtained by scanning leaves. For the audit was measured and scanned at least 100 sheets of 12 sugar sorghum plants.

Test results show that the calculation method for determination of leaf surface for sugar sorghum is more accurate than the carving method (Fig. 3). Thus, when determining the surface area of individual leaves of sugar sorghum by carving method average relative error is ± 9,1%, and by calculation method method - ± 4,2%.
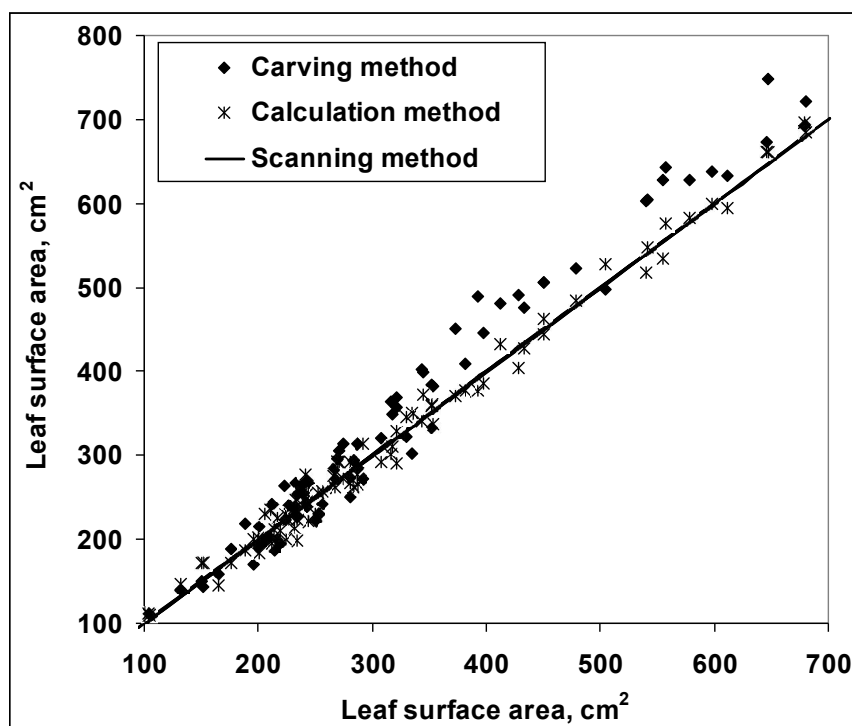
**Fig. 3 Comparison of different methods for determining
the surface area of leaves of sugar sorghum.**

Conclusions:

1 The method for determination of leaf surface, which consists in scanning the leaf plate by flatbed scanner and processing the received image files using special software was developed.

2. Conversion factors for determining the leaf surface of different varieties and hybrids of sorghum sugar by calculation method were established.

3. Experimental verification and assessment of the accuracy for determining the surface area of leaves of sugar sorghum by different methods were conducted

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Анотація

Ганженко О.М.

Методика визначання площі листкової поверхні цукрового сорго

Наведено методику з визначання площі листкової поверхні цукрового сорго, яка полягає у скануванні листкової пластини на планшетному сканері та опрацюванні отриманих графічних файлів за допомогою спеціального програмного забезпечення. Встановлено перевідні коефіцієнти для визначання площі листкової поверхні різних сортів та гібридів цукрового сорго розрахунковим методом.

Ключові слова*: цукрове сорго, листкова поверхня, площа листкової поверхні, планшетний сканер*

Аннотация

Ганженко А.Н.

Методика определения площади листовой поверхности сахарного сорго

Приведена методика определения площади листовой поверхности сахарного сорго, которая заключается в сканировании листовой пластины на планшетном сканере и последующей обработке полученных графических файлов с помощью специального программного обеспечения. Установлены переводные коэффициенты для определения площади листовой поверхности различных сортов и гибридов сахарного сорго расчетным методом.

Ключевые слова: *сахарное сорго, листовая поверхность, площадь листовой поверхности, планшетный сканер*