Digital technologies in quality determination of sunflower seeds

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Abstract. In post-harvest seed processing, there are prerequisites for the introduction of digital technologies to assess its quality, which expand functionality, reduce time and labor costs. Using the scanning of sunflower seed heap to assess its quality in the form of an image allows it to be presented in a color scale, which will improve the measurement accuracy by determining the seed purity class, and its accuracy will depend on the heap seed composition, as well as on the type of grain-cleaning machine. Increasing the scanner resolution will allow achieving accurate measurements. The air-sieve grain-cleaning machine, for which the Patent of the Russian Federation was obtained, uses a computer device in conjunction with technical devices to assess the sunflower seed quality, which makes it possible to obtain the result of its sorting in real time, that is, to improve its quality. This grain-cleaning machine can be used in agriculture as a separate or as part of the ZAV grain-cleaning unit, which will replace expensive cleaning equipment, such as a photoelectric separator, and also replace imported seed-cleaning equipment, for example, the “Petkus” brand for sorting sunflower seeds.

1 Introduction

Currently, the control of the suitability inspection of seed material, the preservation and improvement of its quality are the most important objective of crop farming.

Seeds are one of the main products of agricultural industry, the object of preserving the viability and reproduction of plant material, the key to support the national food security. The successful implementation of high and precise technologies in agriculture is largely determined by the seed quality [9].

The issue of quality assessment of seeds in solving the problem of increasing the efficiency of seed material production is fundamentally important, largely determining the productivity of agrocoenosis and requiring the development of non-destructive methods for monitoring various types of defects and anomalies of both external and internal structures of the caryopsis, the degree of different quality of production seed lots [10].

The current state of the grain production industry cannot provide its necessary efficiency without fundamental transformations. The objective is not only to increase grain production, but also to
improve its quality, which is inextricably linked with advanced technologies and machine complexes for high-quality performance of grain cleaning technological processes [8].

Solving large-scale tasks for the development and implementation of new production technologies for the production, processing and storage of agricultural products, the creation of high-tech machines for the agro-industrial complex, a significant increase in the production of seeds of new domestic varieties cannot be successfully completed without using modern methods of measuring, monitoring and controlling technological processes. The conducted studies have shown that in the Russian agro-industrial complex the development and exploitation of information technologies, as the basic innovations of the fifth technological setup, are at the initial stage, therefore, the evolution of researches, organization of the development and application of digital technologies and management systems in agriculture and refining industry are necessary to accelerate technological development. This is an urgent task and one of the main directions of increasing the competitiveness of domestic agricultural product, which restrains the growth of its exports [1,2].

In recent years, laser scanners are widely used in measuring technology, designed for non-contact measurement and control of surface profile, position, movement, dimensions, recognition of technological objects, level measurement of bulk materials and liquids, 3D models construction and other purposes [1,4].

Based on laser technologies, systems and methods of image processing are being created to automatically determine the shape and size of seeds, reflecting genetic, physiological and environmental indicators that affect the yield, quality and cost of seeds, the methods are being developed to assess the germination energy and uniformity of seeds, the sorting machines are being created, including ones for the study of statistical indicators of seeds of various agricultural crops. The implementation of digital technologies makes it possible to fully use the genetic potential of seeds and improve yields [1,5-7].

As modern domestic and foreign experience shows, hidden grain defects are not identified by standard, mainly visual methods of assessment. To identify them, it is advisable to apply specialized introscopic equipment, including X-ray units with subsequent computer analysis of the resulting images of individual caryopses [3,13].

In the foreign literature, the data on purposeful studies of the structural integrity of agronomic objects that affect their economic suitability and are determined by the specific conditions of growing plants, modes of harvesting and post-harvest processing of grain, is practically non-existent [3].

At every stage of seed preparation (seed cleaning, calibration, rubbing, gravity sorting and pelleting), the seed is stressed, it can lose its energy and become unsuitable for sowing, therefore it is necessary to constantly monitor its condition. Hence, 3D technology is used at every stage of production, which allows using a special program to analyze computer images, determine the qualitative composition of seeds and evaluate them [1].

Calibration is important and allows isolating large-sized seeds from the grain mass, which have high germination capacity in sowing, high germination energy, and which contain a sufficient supply of nutrients. To conduct seed lab test and calibration, it is efficient to apply electro-optical devices, which are fully automatic and capable of conducting the assigned tasks according to a predetermined operation algorithm [14].

The development of a system for detecting various kinds of hidden defects and, on this basis, the creation of automated complex for express-assessment of the seed quality, both mass industrial reproductions and selection samples, as well as assessment of the technological characteristics of grain, should be considered as the most urgent tasks of automatic image analysis in crop production. That will more correctly and promptly allow to take decisions on the intended purpose of seeds and reduce the risks of loss of plant material and material costs.

Digital display during its computer processing allows extracting quantitative and qualitative information and thus move from an intuitive-empirical analysis of an image to an objectively measured one. The essential advantages of digital radiography over the screen-film process, are the simplicity and speed of image acquisition. The image becomes available for analysis by the radiologist
at the end of the exposure. The particular value of using digital radiography lies in the possibility of completely eliminating X-ray film and the associated photochemical process. This makes X-ray examination more cost-effective and environmentally friendly, and digital storage of information allows creating easily accessible X-ray archives. New quantitative forms of data processing open ample opportunities for standardizing the acquisition of images, bringing them to a single quality standard regardless of the time of acquisition or examination. Of no small importance is the emerging opportunity of transmitting images at any distance using computer communications, as well as receiving and discussing the results on-line.

The introduction of digital radiography in practice can transfer the diagnosis of seed material to a new higher technological level [9]. Therefore, the purpose of the research is to diagnose oilseeds, for example, sunflower, in terms of their quality properties after sorting by air-sieve grain-cleaning machines, allowing expanding functionality, reducing time and labor costs.

2. Materials and methods
The object of the study is a heap of sunflower seeds of the “Lakomka” variety.

The studies have been carried out according to the methodology given in the GOST 12037-81. Seeds must comply with the GOST R 52325-2005 “Seeds of agricultural plants. Varietal and sowing characteristics. General specifications”, according to which the varietal and sowing qualities of seeds are determined by the content of seeds of other plants, purity, etc. [11].

3. Results and discussions
To determine the quality of oilseeds after sorting them on air-sieve grain-cleaning machines, a method was developed according to the Patent of Russian Federation № 2693334, which is carried out as follows.

As an object, a weighed amount of a heap of sunflower seeds is used in a number of at least three, which is taken from the total mass of the cleaned heap of oilseeds. The number of weighed amounts is due to the fact that at least three are recommended to reduce the percentage error in measuring according to the GOST 12037-81. Next, an oilseeds heap is leveled in the form of a rectangular flat surface with a layer thickness of not more than 1 cm and each weighed amount is scanned. Three matrices of components are obtained by color with data characterizing the size of the object (wastes and sunflower seeds) by scanning a color image with a “.jpg” file resolution (Figure 1) and a pixel resolution of at least 600dpi per inch, followed by its computer processing using the “Mathcad” program.

Next the total area of all objects on a flat surface is determined by summing all the values of the matrix of components of the same color in pixels. Then the obtained matrices of the weighed amounts are summed up and the average value of the area occupied by wastes indicated in green is obtained, the average value of the area occupied by seeds indicated in blue is obtained, and by the ratio of the areas occupied by waste and seeds (Figure 2), the seed cleaning quality is determined, with values of 99% corresponding to the 1 purity class, 98% – the 2 purity class and 97% – the 3 purity class, seeds of the 2 and the 3 purity classes are delivered for additional processing.

An example of the implementation of the method for determining the quality of sunflower seeds.

From the total mass of the “Lakomka” variety seed heap obtained by an air-sieve grain-cleaning machine of the MVU-1500 type, weighed portions of the heap in a number of at least three, 100g each, have been selected according to the GOST 12037-81. Then each portion is poured, leveled in the form of a rectangular flat surface with a layer thickness of not more than 1 cm on the surface of the Epson Perfection V30 device and scanned. Further, the obtained color image with a “.jpg” file resolution and a pixel resolution of at least 600 dpi per inch has been processed by computer using the “Mathcad” program. The total area of all objects on a flat surface is determined by summing all the values of the matrix of components of the same color in pixels. Then the obtained matrices of weights are summed up and the average value of the area occupied by wastes indicated in green is obtained, the average
value of the area occupied by seeds indicated in blue is obtained and the quality of seed cleaning is determined by the ratio of the areas occupied by waste and seeds, at values of 99% corresponding to the 1 class of purity, 98% – the 2 class of purity and 97% – the 3 class of purity. Seeds of the 2 and the 3 purity classes are delivered for additional processing.

Figure 1. The scanned heap of sunflower seeds of “Lakomka” variety

Figure 2. The sunflower seed of “Lakomka” variety selected from the heap

After processing all three colors, the average value of the number of pixels in the color gamut is determined by dividing the total value of the number of pixels in the color gamut by the average and multiplying by 100 to obtain the percentage of purity of sunflower seeds. Knowing the average value of the brightness for the colors of the object, and comparing with the GOST 12037-81 for all three values of brightness, the purity class of sunflower seeds is determined.

Having processed, the following values of the quality of cleaning sunflower seeds have been obtained: the first weighed amount was 98.82%, the second weighed amount was 99.52%, the third weighed amount was 98.96%. The average value of purity was 99.1%, which corresponds to the 1 purity class.

Based on the experimental studies, a program-algorithm has been developed [12], which provides an assessment of the sunflower seeds quality by the brightness of the color of objects (Figure 3).

To determine the sunflower seeds quality, where there is a device for their determination, an airsieve grain-cleaning machine has been proposed according to the Patent of Russian Federation № 2706193. The technological process of the air-sieve grain cleaning-machine (Figure 4) in sorting sunflower seeds is carried out as follows.

Seed material, after being cleaned in pneumatic channels of preliminary and final aspiration, on a sieve system, comes from the aspiration channel of final aspiration into a truncated conical hopper 11 of device 2 to determine the seed cleaning quality.

In the upper part of the hopper 11 of the device 2 for determining the seed cleaning quality, an automatic sensor 16 of the level of its loading is installed, connected with a gate 10 located at the outlet of the conical seed distributor 9. A chute (not shown in the Figure) is made in the body of the automatic sensor 16, through which the heaps of sunflower seeds pass.

As the hopper 11 is filled with a heap of sunflower seeds, the heap pours through the chutes and sequentially block the optical channels (not shown in the Figure) of the automatic sensor 16. The electrical automatic sensor 16 outputs are included in the output circuit, which changes its conductivity under the influence of changes in the grain level in the hopper 11. If the hopper 11 is filled with components of a heap of sunflower seeds (pieces of pods and stems, broken, feeble and
whole seeds) above the level, then the automatic sensor 16 of the DUZ-1/10 level of its loading gives a signal, and the damper 10 is closed.

**Figure 3.** The flowchart of the sequence of the program blocks for determining the sunflower seeds quality

**Figure 4.** The air-sieve grain-cleaning machine (general layout)
Next, the sunflower seeds enter the outlet channels 12 of the device 2, where the speed of seed movement along the ledges 13 should be 1.5-2 times higher than the speed of their introduction into the outlet channels 12. The seeds enter the weight batchers 3, weighing them, and the excess heap components of sunflower seeds are discharged outside into a hopper (not shown) through a valve (not shown). The time of weighing seeds on weight batchers 3 is 1/2 of the time of movement of seeds along trays 14. In this case, the weighed portion of seeds of 100 g, on weight batchers 3, is scanned by multimedia devices 4 and subjected to computer processing on a personal computer 8 with “Mathcad” software to determine the seed quality of. If the agrotechnical requirements for the purity of sunflower seeds are met, they enter the tanks 7 for their storage. If they do not comply with agrotechnical requirements, they are additionally cleaned by machines 6 [15].

4. Conclusion
In post-harvest seed processing, there are prerequisites for the introduction of digital technologies to assess its quality, which expand functionality, reduce time and labor costs.

Using the scanning of sunflower seed heap to assess its quality in the form of an image allows it to be presented in a color scale, which will improve the measurement accuracy by determining the seed purity class, and its accuracy will depend on the heap seed composition, as well as on the type of grain-cleaning machine. Increasing the scanner resolution will allow achieving accurate measurements.

The air-sieve grain-cleaning machine, for which the Patent of the Russian Federation was obtained, uses a computer device in conjunction with technical devices to assess the sunflower seed quality, which makes it possible to obtain the result of its sorting in real time, that is, to improve its quality.

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