AUTOMATIC QUALITY CONTROL OF FLOW WHEAT TREATMENT

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The paper analyses the urgency of presowing wheat grain dressing. Measures for automatic control of the technological process of flow grain treatment according to its digital image are proposed. A laboratory method for assessing the treatment quality with the archiving of visually perceptible samples has been implemented. It is also possible to use a hardware method based on the pulse image acquisition, which reduces the requirements for speed and processing power of the control system, but does not allow an operator to visually assess the quality of treatment.

A device for obtaining a digital grain image in a pulse mode is proposed. The design of the device takes into account the technological process features of presowing grain processing. As a sensitive element, it has been proposed to use a CCD matrix protected by quartz glass and illumination with a white LED strip or a cold cathode lamp.

The developed methods allow for the first time to introduce an automatic method for controlling the operating modes of seed protectants, both with and without the use of dyes. The methods can be implemented in the laboratory with a selected sample from the grain flow, and directly in the grain flow in the automatic mode without physical sampling. The latter minimizes the contact of the operating personnel with the treated seed material.

At this stage of laboratory experiments, we can ascertain the dependence of coordinates of the vertex of the approximant parabola on the marker amount that is on the grain surface, which in the context of treatment indicates the protectant amount. In practice, this technique must be adapted to the colour of the dye.

The by-side practical result is the possibility of grain contamination control which may indicate a violation of presowing treatment modes.

Keywords: wheat treatment, automatic control, digital image, quality of treatment.

INTRODUCTION

To achieve high yields, the technological process (TP) of seed treatment with working solutions containing substances that promote growth, resistance to diseases and pests in the first days of growth is common. In practice, there is deep bacterial and fungal infection of the seed material, which exceeds 50% [6]. Phytopathogenic infections in the seed grain lead to deterioration of planting qualities, and the decrease in the rate of the plant growth and development [7].

If the agricultural and technical requirements are violated, the laboratory similarity of seeds may be decreased by 10% or more [7]. Field germination can be decreased even more. In accordance with agricultural and technical requirements, the minimum treatment degree is 85%, however, at optimal settings of TP it can reach 90-95% [9].

The purpose of the paper is to justify an information indicator for assessing the performance quality of technological equipment for seed treatment and the technical means for its implementation in production lines. The purpose can be achieved by using the law of large numbers. This is possible due to the use of modern microprocessor imaging tools (digital camera, scanner, web camera). In this case, it is possible to ignore the geometry of the grain and the TP modes, and also consider the treatment process using the "black box" method.

MATERIALS AND METHODS

Traditionally, the quality of seed treatment is controlled by laboratory methods, which are specified in the current normative documents of

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Standard of equipment inspection 01.1-37-429: 2006 "Seed treatment. General technical requirements"» and Engineering documentation 10 10.4-89 "Testing of agricultural machinery.

Machines for seed pretreatment. Testing program and methodology". These methods are aimed at assessing the treatment equipment performance in laboratory conditions. They include a sequence of chemical experiments performed in a given amount of material, which is selected according to certain rules in order to minimize the measurement error [3, 9]. Such methods are long-term ones, require a special laboratory, qualified personnel and are influenced by the human factor significantly. In addition, the control is carried out after the completion of the TP, which makes it impossible to adjust its parameters in the automatic control system (ACS).

To evaluate the quality of seed treatment and develop the technique of hardware evaluation, we used a luminescent marker, the causative agent of which is ultraviolet irradiation, a visual inspection device and developed software for determining the uniformity and completeness of treatment [1]. Controlling the application of the marker in small doses was checked by electrisation of the disinfectant and grain with unlike charges.

The essence of the technique is to obtain a digital image of the sample during processing, or after it, under the same conditions of external illumination. Under laboratory conditions, the grain was lightened with an ultraviolet lamp and photographed in a dark room with a camera with the same settings. Diffused illumination at the level of the sample was 2 lux. The result was saved in a BMP graphic format file as a 24-bit colour drawing. To automate the experiments, special software was developed (Figure 1), the main tasks of which were: obtaining colour image parameters; obtaining graphs of a discrete series of colour distribution; export of data.

RESULTS AND DISCUSSION

Earlier, the team of authors proposed an electrical and technical complex for seed material treatment using electromagnetic fields [1, 5]. The proposed complex allows to improve the treatment quality, reduce grain damaging and energy costs for additional drying. The declared values are achieved due to grain falling through an electrically charged aerosol cloud.

The first task, which was solved on the basis of this method, is to make reliable conclusions

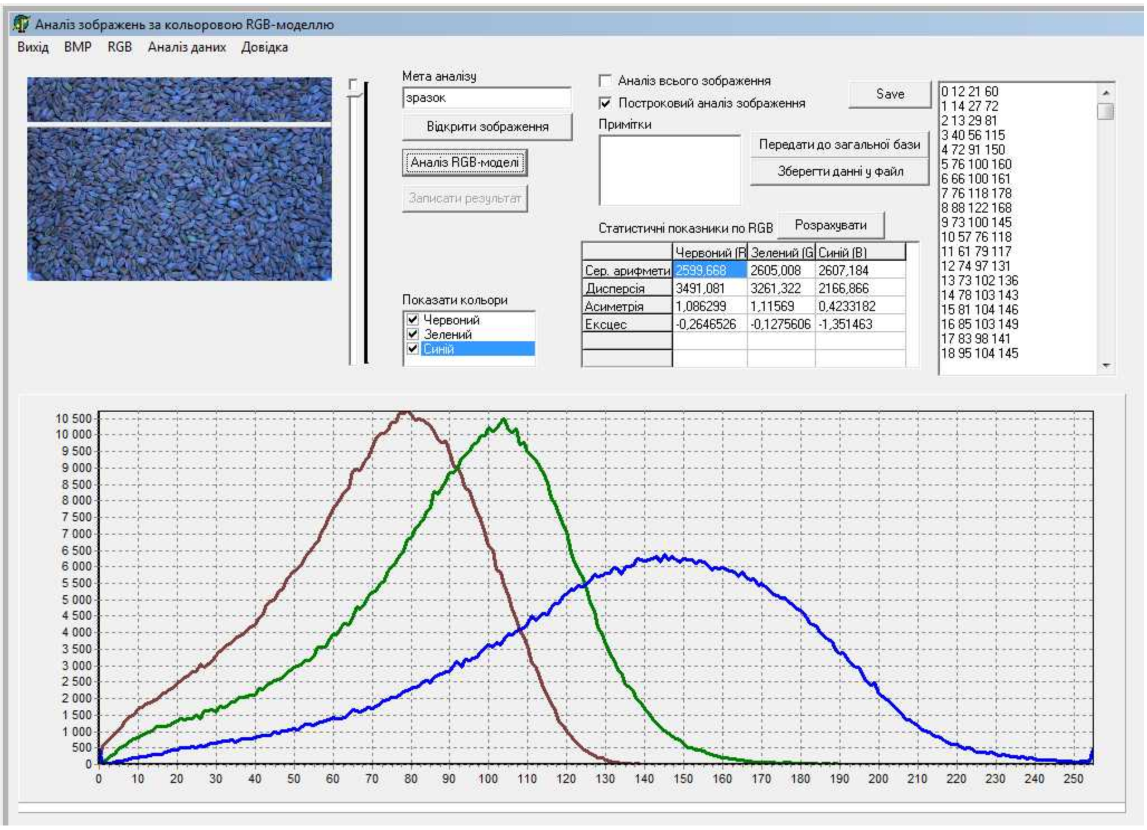

Figure 1. The dialog box of the program

on the protectant action mode, which would fully characterize the entire TP, on the basis of the tone distribution data which are obtained from the images of the grain flow. The theoretical solution of this question is based on the law of large numbers [4]. According to the research purpose, this law is used to determine the minimum image size sufficient for reliable estimation of TP.

Using Student's test it was proved that when working with a wheat image size of 750x750 px (scanning or photographing resolution of 300 dpi), the average values of tone frequencies statistically differ insignificantly. In accordance with the law of large numbers, the recommended number of scanned grains is 384 [4]. The nearest image to such quantity of grains, has the size 1000x1000. This size is taken as a basis.

The resulting distributions (Fig. 2) were analysed by statistical indicators, which characterize the total distribution and separate distribution for each tone. The analysis of statistical indicators of distributions has not allowed to distinguish the main colour and statistical parameter as a criterion of quality, because The average tone value, the dispersion of their distribution, the asymmetry and the kurtosis in all cases showed a linear correlation coefficient less than | 0.5 |.

The second variant of the analysis (evaluation of each tone) with the help of the linear correlation coefficient has turned out to be more informative (Figure 2). As a result of the calculations, the red colour does not have tones with the correlation coefficient greater than |0.8|. In turn, green and blue colours have a fairly large number of tone sections with the correlation coefficient greater than |0.9| (Figure 2).

In order to increase the reliability of the approximant, blue shades of 70 to 130 are used for further analysis. A parabolic function with a vertex at the extremum point most fully covers this range. In this range, the regression equation can be represented in the form of a parabolic function

$$y_{x2} = a_0 + a_1 \cdot x + a_2 \cdot x^2, \qquad (1)$$

where a_0, a_1, a_2 are the coefficients of the regression equation.

The coefficients of the regression equation (1) are determined by the method of least squares, for this we use the corresponding system of normalized equations [4]. For the analysis the arithmetic mean tone values of 4 samples of each experiment are used. The

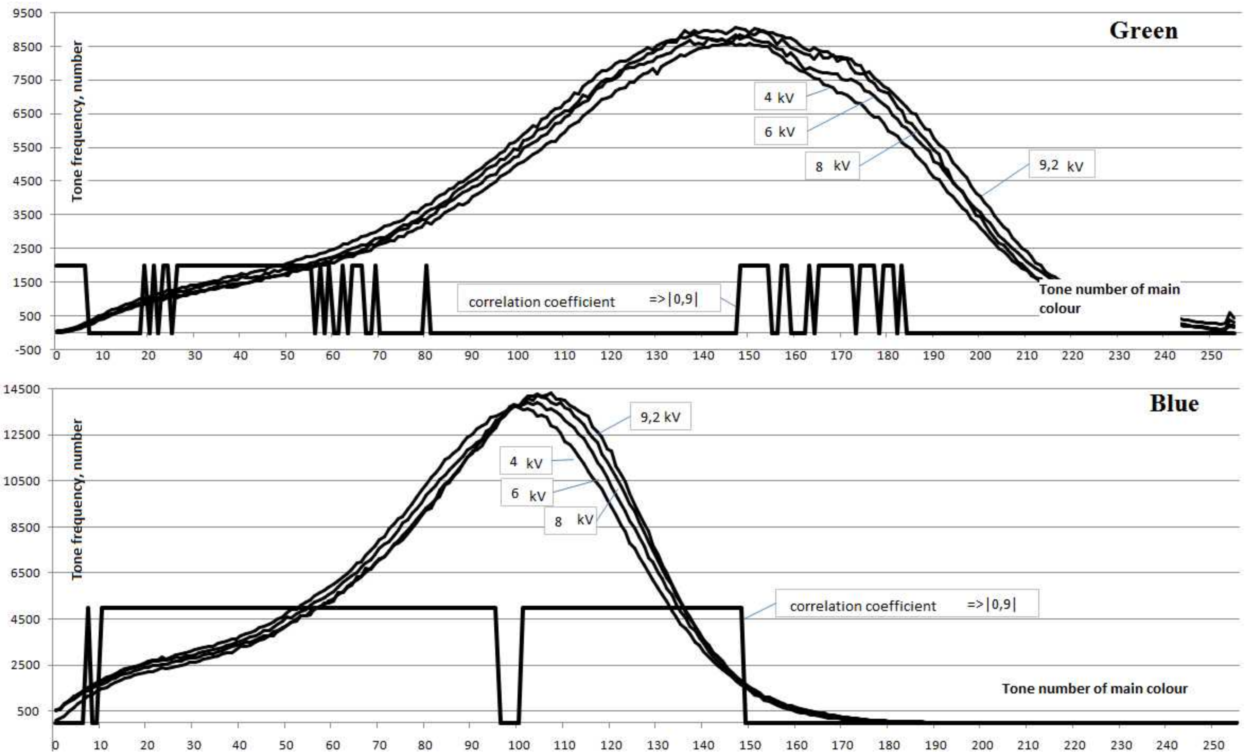

Figure 2. Distribution of image colour tones of seed materials under ultraviolet irradiation and aerosol treatment with voltage of 4, 6, 8 and 9,2 kV

samples do not have statistically significant errors for each tone, which were determined by the Student's test.

For practical use as an informative indicator, it is necessary to determine which of the parameters of the regression equation has the maximum coefficient of linear correlation, the relationship between processing parameters and the resulting coefficients of the regression equation. As an information indicator, the coordinates of the vertex of the parabola are used

$$\left(-\frac{a_1}{2a_2};\quad -\frac{4a_2 \cdot a_0 - a_1^2}{4a_2}\right), \qquad (2)$$

The results of the calculations show (Table 1) that it is most rational to use the coordinates of the vertex of the parabola as an informative indicator.

Table 1 - The value of the coefficients of the regression equations and the coefficient of linear correlation

Voltage, kV / Tone	4	6	8	9,2	Coefficient of linear correlation
a_2	-8	-8	-8	-8	0,94
a_1	458	480	507	510	0,987
a_0	6617	5869	5154	5014	-0,99
vertex x	29	31	33	34	0,997
vertex y	13300	13404	13544	13681	0,987

At this stage of the laboratory experiments, the dependence of the parabola vertex coordinates on the amount of the marker located on the grain surface is determined, which in the context of treatment indicates the amount of protectant. It should be added that most modern protectants have a dye that is allows you to evaluate the quality of treatment visually and rather roughly. In practice, this technique must be adapted to the colour of the dye.

In order to use this method under production conditions, it is necessary to develop a methodology and device for implementing automatic monitoring in the flow. This task is complicated due to the emergence of a number of technological issues: the location of the installation in the production line; technological operating conditions; the choice of the scanning device type; the possibility of timely maintenance and repair.

As a result of the analysis of external factors and adaptation of the measurement technique, pulsed obtaining of a digital grain flow image is proposed. In this case, an image is analysed with a width of 1 pixel, but not a static image of a given size. It is possible to receive information at a given periodicity. The hardware implementation is undemanding to the speed of information processing (Figure 3).

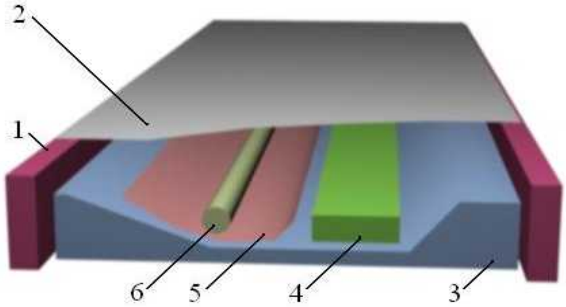

Figure 3. Construction of the device for original image obtaining: 1 - body; 2 - glass; 3 - base; 4 - sensing element (CIS matrix); 5 - reflector; 6 - light source (cold cathode lamp or LED strip).

proposed device works in this way: the body 1 is fixed, the glass 2 directly contacts the grain flow, which is minimally illuminated by an extraneous (external) light source at a predetermined time interval, the lamp 6 is turned on and provides the necessary illumination conditions for the operation of the matrix 4 by means of which an input signal is generated.

To implement the method for determining the parameters of grain treatment based on its digital image, it is necessary to select a scanning device taking into account the form of the matrix (4, Fig.3), as it is the most important part. Most modern scanners use two types of matrices (Table 2). The case of the CIS-scanner is flat, in comparison with a similar CCD-device (its height is about 40-50 mm).

If one takes into account that obtaining the initial data will be carried out in the flow of grain material, it is necessary to ensure that the most accurate original digital image is obtained for further analysis [1, 8]. This can be achieved by using a matrix with a greater depth of field.

The error in the spread of the levels of colour shades, which differ in the standard CCD matrices, is almost twice that of the CIS matrices, which indicates a qualitative difference between the actual colour and its digital representation of different types of matrices.

Table 2 - Advantages and disadvantages of scanning device matrices

Matrix type	Advantages	Disadvantages
CCD	High optical resolution (up to 2400 dpi) Long term of lamp operation Scanning quality Large scanning depth	High cost (with respect to CIS-matrices) Long lamp heating before scanning An additional power source.
CIS	Small size Fast start Low power consumption (USB-powered) Autonomy	Limited optical resolution (up to 1200 dpi) Influence of side lighting Small scan depth Poor scanning quality

To ensure the necessary quality of the image of grain material, the type and properties of the glass are taken into account, which separates the grain from the sensitive element of the optical system of the device. It should be taken into account that during the scanning of the grain in the flow, its possible damage (scratches, microcracks). Therefore, it is necessary to simultaneously consider the optical and mechanical characteristics of the glass. We propose to use quartz glass, which has a minimum refractive index and is most resistant to mechanical influences.

When discerning information about the grain flow is discerned, it should be taken into account that its reliability will depend on the width of the flow and the number of images. In this case, statistical indicators of the distribution of tones according to the length of the image are informative. You can only limit to the arithmetic mean. An additional advantage of this method is the possibility of determining additional technological parameters of the grain flow. At this stage, we are talking about contamination.

In accordance with the proposed method, a digital image of wheat is obtained at three points (Fig. 4). The diagram of the examined tones is presented in Figure 5. Standard statistical characteristics were used for their analysis (Table 3).

Table 3 - Results of statistical processing of diagrams (Figure 2)

Indicate \ Weediness, %		0	3	6	Coefficient of linear correlation
Red	Arithmetical mean	151	161	168	0,99
	Standard deviation	39,4	38,5	43,0	0,77
Green	Arithmetical mean	97,3	106	117	1,00
	Standard deviation	40,1	43,1	52,15	0,96
Blue	Arithmetical mean	77,6	82,9	91,9	0,99
	Standard deviation	31,4	34,3	40,27	0,98

Figure 4. Sample of digital image of "Zolotokolosa" winter wheat with plant impurities: 1 - weediness 0%; 2 - weediness of 3%; 3 - weediness of 6%

CONCLUSION

The automated control of the TP of flow rain treatment according to its digital image is realized. A laboratory and hardware method for controlling the quality of etching based on pulse imaging, which reduces the requirements for the speed and processing power of the control system, is presented.

The design of a device for obtaining a digital image of grain in a pulsed mode, considering the features of the technological process of presowing grain processing is proposed.

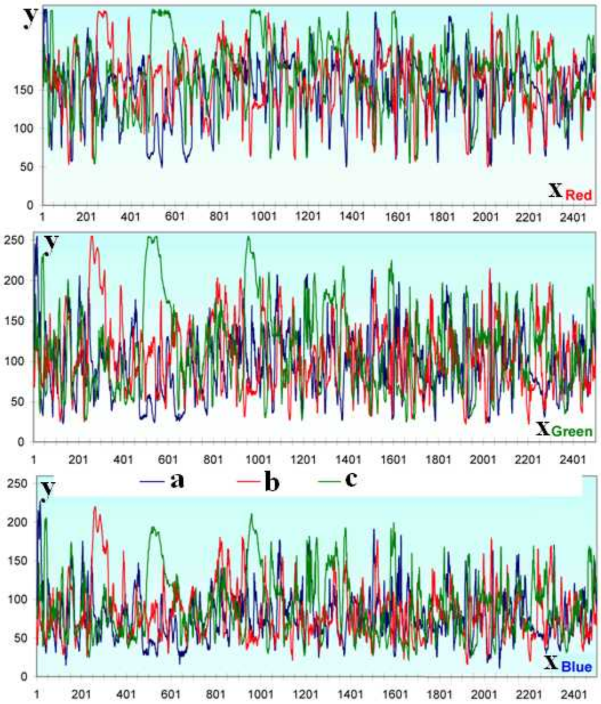

Figure 5. Examined toness of the RGB-model according to the image length (x is the image length, px, y is the tone number, a is the weediness of 0%, b is the weediness of 3%, c is the weediness of 6%)

The developed methods allow for the first time to introduce an automatic method for controlling the operating conditions of seed treatment, both with the use of dyes and without them. Control of the technological treatment process is carried out in the laboratory with sampling from the grain flow, and directly in the flow of grain material in automatic mode. The latter minimizes the contact of the staff with the treated seed material.

At this stage of laboratory experiments, we can ascertain the dependence of the coordinates of the vertex of the approximant parabola on the amount of disinfectant that is on the surface of the grain. In practice, this technique must be adapted to the colour of the dye. A by-side practical result was the possibility of controlling grain contamination, which may indicate a violation of presowing treatment modes.

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