**Electronic Moisture Meter for Onion Seeds**

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**Abstract.** When considering the process of moistening bulk solids for pre-sowing electrical treatment, it is necessary to take into account the heterogeneity of all layers of the seed material. Especially, when moistening onion seeds, it is necessary to take into account some features of moistening such seeds: firstly, dry onion seeds have a very high electrical resistance (the initial moisture content of the seeds is about 4.3%) and secondly, it is necessary to limit the maximum moisture content during a single moistening of seeds before sowing (within 30 ÷ 32%). Since excess moisture is filtered through the layers of the onion seed and accumulates at the bottom of the vessel. In this case, a conductivity circuit is formed through the moisture at the bottom of the vessel and the efficiency of electrical treatment of moistened seeds decreases. The moisture content of onion seeds was also studied using a Wile 55 moisture meter. The same moisture meter was used as a calibration device in the manufacture of an electronic moisture meter. The article also contains an algorithm for measuring and monitoring the moisture content of onion seeds for their high-quality moistening. The work also presents a single-line electrical circuit that performs electronic measurement of onion seed moisture. Based on the results of the measured indicators, conclusions are made about the possibility of further intellectualization of the electronic seed moisture meter.

**Keywords:** Humidification and electrical treatment of onion seeds, humidity measurement with an electronic moisture meter, automation and intellectualization of the measurement process

**INTRODUCTION**

Over the last decade, a lot of work has been done in the world and in our country to further improve the system of measuring the moisture content of seeds and agricultural products.

The authors studied the regulatory documents "System of Measuring the Moisture Content of Grain and Grain Products" and "Urgent Replacement of Obsolete Equipment with New-Generation Devices, Development and Harmonization of National Standards for Direct and Indirect Methods of Determining the Moisture Content of Grain and Grain Products." [1]. Researchers have reviewed various methods for assessing the moisture content of seeds and have studied the possibility of analyzing data related to seed processing and storage (drying versus increasing moisture content) by determining the relative moisture content of seeds [2].

**LETERATURE SURVEY**

Determining the moisture content of seeds is very important and helps to analyze the physiological state of the seeds. The standards and methods for moistening dry onion seeds are discussed below.

1. Indian J. PI. Genet (1995) [3] studied the moisture retention levels of onion seeds. The aim of this study was to determine how well onion seeds were stored at low seed moisture levels in ambient conditions compared to medium-term conditions in the genebank. The moisture content of the selected seeds ranged from 1.66 to 7.5%. Germination and germination energy were taken as criteria for assessing seed storage. Seeds stored at 4.0÷4.5% moisture at ambient temperature retained their viability. In the experiment, laminated aluminum foil (LAF) bags and metal boxes with rubber lids were used as containers for onion seeds with moisture levels of 1.6 and 2.8%. The researchers measured the moisture content of onion seeds using a simple moisture meter.

2. Denmukhammadiev et al. (2024) [4] developed software for a sensor that measures the moisture level of agricultural seeds, and based on it, an electronic moisture sensor was created. Pagare et al.(2023) [5] study, several engineering calculations were conducted for onion seeds at different moisture levels. Changes in moisture content affect the density properties of the seeds, as well as all linear dimensions. This study will contribute to the promotion of environmentally friendly and resource-efficient seed production, minimize waste, and increase agricultural productivity. Yalçin et al.(2009) [6] studied the moisture-dependent physical properties of onion (Allium cepa L.) seeds. As a result of the experiments, it was found that the mass of 1000 seeds increased from 3.85 to 4.33 g, the filling factor from 0.680 to 0.688, the moisture content from 7.81% to 23.99%, and the coefficient of static friction for all the studied surfaces, respectively: rubber (from 0.227 to 0.309), aluminum (from 0.159 to 0.228), stainless steel (from 0.149 to 0.195), and galvanic iron (from 0.189 to 0.244). It was found that changes in the moisture content of onion seeds led to changes in their physiological properties.

3. Wayangkau et al. (2021) [7] state that the use of the Internet in agriculture is of great importance to improve crop yields. The objective of this study was to establish an automatic monitoring system for onion cultivation and measuring the soil moisture in which onion seeds were planted using an Arduino microcontroller. The Arduino microcontroller was integrated with component devices to ensure its operation and connected to an analysis sensor. The results of this study show that the tools and systems are based on maintaining soil moisture and temperature, as well as soil conservation and providing innovative solutions. Stuart et al. (2021) [8] conducted research into methods for measuring grain moisture and other food quality indicators based on electrical properties. The article presents the results of measurements of electrical resistance, electrical conductivity, radio frequency capacitance, temperature, bulk density and dielectric properties of a sample for determining the moisture content of grain crop seeds. This paper describes the characteristics of special devices developed for rapid and accurate measurement of seed moisture.

The above approaches reflect the diversity of methods, means of measuring and monitoring the moisture content of agricultural crop seeds (in particular, onion seeds), each of which has its own unique advantages and disadvantages. The gradual transition of methods and means of measurement to an electronic basis allows for achieving an increase in the accuracy of the results obtained. Further research and development continues to create more accurate and easy-to-use electronic measuring devices and systems for practical application in various measurements.

**METODS**

**Determining the Specific Gravity of a Container (for Onion Seeds)**

The measuring vessel was made of galvanized metal sheet in the form of an open cube with a side of 2.5 cm. The weight of the empty measuring vessel and the vessel filled with onion seeds was measured on an EC-K02 electronic scale (accuracy class 0.1%) (the measurements were repeated three times).

The bulk density of granular, loose seeds is determined by the following formula:

(1)

Where is the mass of the measuring vessel, kg; is the mass of the measuring vessel together with the test material (seed), kg; is the volume filled with the test material in the measuring vessel, ; is the volume of the vessel, ; is the filling coefficient of the measuring vessel.

The above-described methods and measuring devices were used to conduct experiments with moistened seeds. The moisture content of the seed material was ensured by adding a certain amount of water in each experiment. With each subsequent addition of water, the seeds were thoroughly mixed with a plastic spoon.

**TABLE 1.** Results of measuring the initial moisture content of onion seeds using the Wile 55 electronic moisture meter

|  |  |  |  |
| --- | --- | --- | --- |
| **No** | **Humidity of onion seeds Andijan-Karatol, %** | **Humidity of onion seeds Istikbol, %** | **Error of the electronic moisture meter Wile 55, %** |
| 1 | 4.3 | 4.1 | 1.1 |
| 2 | 4.1 | 3.85 | 1.1 |
| 3 | 4.3 | 3.9 | 1.1 |

The results of measuring the initial moisture content of onion seeds using the Wile 55 (Figure 1) electronic moisture meter are presented in the table below (see Table I), which summarizes the data for 3 cases.

We measured the initial moisture content of onion seeds of different varieties based on experiments (W0=3.9÷4.3%). The above literature analysis shows that the initial moisture content of onion seeds is in the range of 8÷10%.

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| **FIGURE 1.** The process of measuring the moisture content of onion seeds using a Wile 55 electronic moisture meter |

The results of onion seed moisture measurements (based on average values) are shown in Table II. Data analysis shows a decrease in % moisture depending on the increase in the moistening portion by 10 g of water. Within 32% of moistening, moisture ceases to be absorbed by the seeds and leads to excess moisture.

**TABLE 2.** Onion seed moisture measurement results (based on average values)

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| --- | --- | --- | --- | --- | --- |
| **No** | **Mass of onion seeds, g** | **Wet weight of onion seeds, g** | **Humidity, %** | **Room temperature, oC** | **Relative humidity in the room, %** |
| 1 | 100 | 110 | 20.95 | 23 | 50 |
| 2 | 110 | 120 | 27.15 | 23 | 50 |
| 3 | 120 | 130 | 30.35 | 23 | 50 |
| 4 | 130 | 140 | 31.9 | 23 | 50 |

**RESULTS AND DISCUSSIONS**

An algorithm for the electronic control of onion seed moisture has been developed (Figure 2). In this case, based on the results of calculations and measurements, it is necessary to develop an information base that determines which electrophysical and mechanical parameters are important for the system and which are measured. According to the specified algorithm, when the system is started, the physical parameter of the seed is first entered. Since the electrical conductivity of seeds directly depends on the moisture level of the moistened seeds, additional moisture is added to the seeds to control the conductivity. As a result, the electrical conductivity of the seeds begins to reach a certain (limiting) value from some initial value, and the data receiving unit displays the moisture value on the LCD screen. During this process, when the moisture content of the seeds reaches the specified value, the system completely stops the process of additional moistening of the seeds. Otherwise, moistening continues. The electronic moisture control sensor can be used to measure and control seed moisture in both stationary and rotating technological processes (via sliding contacts).

Based on the results of the experiment, the thermophysical properties of the onion seed layer were determined depending on the humidity. This requires precise measurement of the humidity of onion seeds. For this purpose, an electronic humidity control sensor was developed and an electronic program was created. The use of an electronic humidity sensor allows determining the timing of onion seed treatment in alternating electric current of industrial frequency (AC FC), as well as regularly monitoring the humidity of seeds and creating optimal treatment conditions.

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| **FIGURE 2.** Algorithm of electronic program for monitoring onion seed moisture |

Resistance-based methods for measuring onion seed moisture usually allow measuring the humidity level with high accuracy. The process of measuring the moisture content of onion seeds using an electronic moisture sensor and the internal electrical circuit of the moisture sensor module are shown in Figure 3 and 4.It measures sensitivity and measurement accuracy to within 1%, and relative humidity in the range from 0 to 100%.

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| **FIGURE 3.** The process of measuring the moisture content of onion seeds using an electronic moisture sensor |

The humidity sensor module wiring diagram includes: a humidity sensor (DHT), a LED indicator lamp (LED1), two resistors (R1, R2) of 5.1 and 1 kOhm respectively, a capacitor C1, a voltage source (VCC) and ground electrodes (GND).

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| **FIGURE 4.** Internal Wiring Diagram of the Humidity Sensor Module |

Figure 5 shows the relationships between U and I.

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| **FIGURE 5.** VAC obtained in onion seeds at moisture content W1=22%, W2=27% and W3=32% |

During statistical analysis of the characteristics presented in the figure (Figure 5), it was found that the relative measurement error at low values of electrical parameters (current and voltage) slightly exceeds the relative error calculated at their high values. This indicates the admissibility of electrical processing of moistened onion seeds in the voltage range of the electric heating device from 200 to 240 V.

**CONCLUSION**

Moisture reaches the seed kernel and revives it. In the physical processes considered in the article, by additionally moistening onion seeds with the initial moisture, a new effect is achieved as a result of the passage of electric current through infections on the surface of seeds with a threshold moisture content (31-32 %). That is, the seeds become healthier and their quality improves. Achieving the ability to control seed moisture using an electronic moisture sensor in this technological process created the initial conditions for the intellectualization of the proposed method.

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