JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS
VOLUME 5, ISSUE 04
MONTHLY JOURNALS
ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

EVALUATION OF PHYSICAL, MECHANICAL, AND STATISTICAL PROPERTIES OF WHEAT SEEDS AND THEIR INFLUENCE ON SOWING TECHNOLOGIES

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Abstract. This study investigates the physical and mechanical properties of wheat seeds and their influence on sowing efficiency using statistical and experimental approaches. The geometric dimensions and mass of the seeds, along with their variance and coefficient of variation, were determined. The results indicate that low variability in seed size ensures stable seed flow, whereas high variability in mass negatively affects seed metering accuracy. The findings highlight the importance of considering seed properties in improving sowing performance.

Keywords: variance, standard deviation, coefficient of variation, seed metering, sowing quality

Introduction.

Globally, the majority of agricultural land is allocated to cereal crops. In particular, more than 700 million hectares out of the total 1 billion hectares of cultivated land worldwide are devoted to grain production. In Uzbekistan, over 1 million hectares of irrigated land are currently used for cereal crops, 137 thousand hectares for rice cultivation, and nearly 300 thousand hectares of rainfed land are sown with grain crops [1].

Today, global food security is one of the priority issues in the agricultural sector. In recent years, climate change, limited resources, and population growth have increased the need to enhance the productivity of cereal crops [2]. Wheat (*Triticum aestivum* L.), in particular, is one of the main staple crops, and its production efficiency largely depends on sowing quality. Modern studies indicate that up to 15–25% of losses during the sowing process are associated with the uneven distribution of seeds [3].

These issues lead to reduced germination rates, disruption of crop stand uniformity, and a significant decline in final yield. Practical observations and field experience show that in existing grain seed drills, the uniform distribution of seeds largely depends on the physical and mechanical properties of the seeds. Specifically, grain size, mass variability, and moisture content are key factors influencing this process [4].

Over the past five years, numerous studies have extensively examined the flow mechanics of granular materials and their impact on technological processes [5]. However, a critical scientific gap remains: although many studies have addressed seed flow control, the relationship between the physical and mechanical properties of seeds and the technological process has not been comprehensively analyzed. In particular, determining the functional relationship between the statistical parameters of wheat grains (variance, standard deviation, coefficient of variation) and sowing quality remains an aktual scientific problem.

This study aims to fill this gap by providing an in-depth analysis of the physical and mechanical properties of wheat grains and scientifically substantiating their influence on the sowing process. The results of this research will serve as a basis for developing scientific and practical solutions to improve resource efficiency and increase crop productivity in agriculture.

Cereal crops occupy the majority of agricultural land worldwide. More than 700 million hectares out of 1 billion hectares of cultivated land are devoted to grain production. In

Uzbekistan, over 1 million hectares of irrigated land are allocated to cereal crops, along with significant areas of rainfed land.

Materials and Methods.

The research object consisted of soft wheat (*Triticum aestivum* L.) grains grown under local conditions and selected for sowing purposes. A sample size of $n = 50$ grains was adopted. This size represents a standard small sample commonly used in laboratory conditions for evaluating physical parameters and is considered sufficient for preliminary statistical analysis [6]. At the same time, to ensure the reliability of the results, each measurement was recorded individually.

During the selection of grains, the following criteria were applied:

- absence of visible external defects;
- belonging to the same variety;
- no mechanical damage;
- absence of disease symptoms.

This approach minimizes the influence of external factors on experimental results.

Measuring Instruments and Accuracy.

The following instruments were used in the study:

- a vernier caliper for measuring grain length and width (accuracy ±0.01 mm);
- a laboratory electronic balance for determining grain mass (accuracy ±0.001 g).

The precision of these instruments increases the reliability of the results and reduces measurement errors.

Determination of Geometric and Mass Parameters.

For each grain, the following parameters were measured:

- length (L, mm);
- width (B, mm);
- mass (m, g).

All measurements were carried out individually, and the results were recorded in tabular form for subsequent statistical analysis. Geometric parameters are of particular importance in determining the movement behavior of seeds in seed drills, as they directly influence flow density and continuity.

Size and Shape Characteristics.

Wheat grains vary in size and shape. Well-formed grains with uniform length improve sowing quality, which in turn contributes to higher yields. Smaller grains often indicate lower quality and may also be affected by diseases. In this study, the lengths of 50 grains were measured using a vernier caliper.

Arithmetic Mean Calculation.

The arithmetic mean is the simplest and most widely used measure of central tendency. It was calculated by summing the masses of all wheat grains and dividing this total by the number of grains in the sample (50).

$$\bar{x} = \frac{\sum x}{n}$$

In this context:

$\bar{x}$ – arithmetic mean value;

$\sum x$ – the sum of all measured values;

n – the number of experiments (observations).

Standard deviation (σ) is a measure of how widely the data are dispersed relative to the mean value. A low (small) standard deviation indicates that the data points are closely clustered

around the mean, whereas a high (large) standard deviation indicates that the data are more widely spread.

$$S=\sqrt{S^2}=\sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

Coefficient of variation (CV) is the ratio of the standard deviation to the arithmetic mean. It indicates the relative variability of the data set. The higher the coefficient of variation, the greater the dispersion of the data around the mean value. This parameter is typically expressed as a percentage**.**

$$V=\frac{S}{\bar{x}}100$$

Results and Discussion.

During the study, a statistical analysis of the morphometric parameters of the sampled wheat variety was carried out, namely grain length, width, and mass. Table 1 presents the arithmetic mean (*M*), standard deviation (*SD*), coefficient of variation (*V*, %), measurement error (*E*), and mean absolute deviation (*MAD*) for these measured parameters.

Table 1

Morphometric and statistical characteristics of wheat grains

No.	Grain dimensions:	M	SD	V, %	Me	MAD
1	Length, mm	6.76	0.41	6.10	0.06	0.86
2	Width, mm	3.07	0.26	8.39	0.04	1.19
3	Mass, g	4.92	0.88	17.82	0.12	2.52

Results and Discussion.

The average grain length was found to be 6.76 mm. The standard deviation was 0.41 mm, which corresponds to a coefficient of variation of 6.10%. The measurement error was 0.06 mm, while the mean absolute deviation (MAD) was 0.86.

For grain width, the average value was 3.07 mm, the standard deviation was 0.26 mm, the coefficient of variation was 8.39%, the measurement error was 0.04 mm, and the MAD was 1.19.

The greatest variability was observed in grain mass: the mean value was 4.92 g, the standard deviation was 0.88 g, the coefficient of variation was 17.82%, the measurement error was 0.12 g, and the MAD was 2.52.

The results indicate that the dimensions of the sampled wheat grains fall within the established standards, and the selected seeds are of high quality and suitable for sowing.

Conclusion.

In this study, the physical and mechanical properties of wheat grains were thoroughly investigated, and their role in improving modern sowing technologies was substantiated. The obtained results show that the variability in grain dimensions (length and width) is relatively low, indicating a high degree of uniformity in shape and size. This enhances the possibility of uniform seed distribution through seed drills.

At the same time, a higher variation in grain mass was observed, which may lead to certain irregularities during the sowing process. Nevertheless, the overall indicators confirm that the seed wheat meets the required quality standards.

The findings suggest that incorporating control systems in seed delivery mechanisms, taking into account the physical and mechanical properties of wheat grains, can improve sowing quality, ensure uniform seed placement, and ultimately increase crop yield.

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