Scientific basis of selection of seeding seeds from the starting material

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Abstract. Based on the analysis of existing methods for isolating sowing seeds and their shortcomings, the presented work presents the principle of disclosing the manifestation of the biological usefulness of seeds and the regularity of their change, which made it possible, based on its single feature in a complex display of the value of the mass of seeds in its variational distribution, to calculate the use of the middle part of it in as a seed with a delineation of the degree of their biological full value by the size of the mass of seeds.

1. Introduction

Cotton seeds in their mass presence in the general population are characterized by a stochastic state, in which each mass of seeds corresponds to a certain value of the mass of the embryo, seed coat with the corresponding density and volumetric size and thickness of the seed coat, a change in which undoubtedly affects the indicator of biological their usefulness.

The recommendations for the use of the size of the mass of seeds [7], the size of the dimensional selectin [3], [16], density [11], the combined scheme of their use [11], [17] presented without disclosing the physical essence of the selection of sowing seeds are contradictory.

Practice shows that all the above recommendations for the preparation of sowing seeds are characterized by an underestimated yield relative to the expected yield according to the capabilities of the cotton variety of the original sowing material. In this regard, in the absence of scientific substantiation, it is proposed to use the middle fractions of the isolated seeds as a seed [10], [8].

To increase yields, the main attention was paid to the introduction of mineral fertilizers [12], stimulation with optical radiation [15] radioactive rays [2], laser radiation [4], and ultraviolet radiation [18], stimulation under the influence of an electric field [19]. However, the above methods of stimulation with some increases in germination do not give a significant increase in yield versus control, caused by the presence of seeds of different quality in terms of their biological usefulness.

Therefore, the development of the biological foundations of sorting with varying quality indicators of seeds to obtain a stable indicator of the obtained high yield of cotton is an urgent requirement of time in realizing the completeness of achieving economically valuable varietal traits and properties of cotton.
2. Materials and methods

In solving this goal, cotton seeds of the An-Bayaut 2 variety were considered. In the samples taken, measurements were taken of the length \( a_i \), width \( b_i \) and thickness \( c_i \) of each seed, the size of their masses \( m_i \). The weight of the embryo is determined by a cut along the length of the seed \( m_{b_i} \), seed coat \( m_{b_i} \), the thickness of the lateral part of the seed coat of the peel is determined \( \delta_{b_i} \), corresponding width \( b_i \) and thickness \( c_i \) of seed as well as the thickness in the chalase area \( \delta_x \).

Measure length difference \( a_i \), width \( b_i \), thickness \( c_i \) of seed and seed coat thickness \( \delta_{b_i} \), \( \delta_{c_i} \) and \( \delta_x \) the size of the embryo along the length is determined \( a_{z_i} \), in width \( b_{z_i} \) and in thickness \( c_{z_i} \).

\[
(a_i = a_{z_i} - 2\delta_{b_i}, b_i = b_{z_i} - 2\delta_{c_i}, c_i = c_{z_i} - 2\delta_x).
\]

The volumetric size of the seed and embryo, taken according to the shape of the ellipsoid of rotation, are determined according to the expression.

\[
V_{c_i} = \frac{\pi a_{c_i} \cdot b_{c_i} \cdot c_{c_i}}{6} \tag{1}
\]

Where \( a_{c_i}, b_{c_i}, c_{c_i} \) - dimensional indicators of length, width and thickness seed \( (a_{c_i}, b_{c_i}, c_{c_i}) \) and the embryo \( (a_{z_i}, b_{z_i}, c_{z_i}) \).

The difference in the volumetric size of the seed \( V_{c_i} \) and the embryo \( V_{z_i} \) determined the volumetric size of the seed coat

\[
V_{c_i} = V_{c_i} - V_{z_i} \tag{2}
\]

Seed density \( \gamma_{c_i} \) embryo \( \gamma_{z_i} \) and the seed coat of the seed rind \( \gamma_{k_i} \) calculated calculated from the well-known expression

\[
m_{c_i,k_i} = \gamma_{c_i,k_i} \times V_{c_i,k_i} \tag{3}
\]

Where \( \gamma_{c_i,z_i,k_i} \) - density of the seed, embryo, seed coat mg/mm³; \( V_{c_i,z_i,k_i} \) - volumetric dimensions of the seed, embryo, seed coat, mm³; \( m_{c_i,z_i,k_i} \) - mass of seed, embryo, seed coat, mg.

The density of the embryo \( \gamma_{z_i} \) is a reflection of the concentration of its chemical composition according to the presence of proteins, starch, fats, vitamins, enzymes, which are mainly contained in the cotyledons, i.e. in the primary leaves of the embryo of cotton seeds. When the seed swells, the chemical composition of the embryo creates oxidative processes that activate the vital activity of cells by converting the chemical composition of the embryo into neoplasms in the form of a seedling with the release of the primary root. In this case, the embryo root, due to the abundance of supply of proteins, amino acids, sulfohydrate elements and peroxidase enzymes [14], is the first to start growing during seed germination.
This gives reason to believe that the density of the embryo “\( \gamma_{\text{iz}} \)” by the presence of the degree of concentration of the chemical composition of the embryo is an indicator of the energy state of the seed, the value of which depends on the volumetric size of the embryo “\( V_{\text{iz}} \)” and its mass “\( m_{\text{iz}} \).”

The density of the seed coat “\( \gamma_{\text{ik}} \)” is related to its strength, the increasing value of which, depending on the size of the seed, affects the degree of moisture absorption.

According to E.G. Kizilova [6] large seeds absorb water less than smaller ones. This suggests that large seeds, both in terms of the degree of moisture absorption and the degree of strength of the seed coat, manifested by its density “\( \gamma_{\text{ik}} \)” in relation to its volumetric size “\( V_{\text{ik}} \),” affect the duration of seed emergence. In this case, the mass of the seed coat “\( m_{\text{ik}} \)” can be considered as an indicator of the resistance to seedling emergence.

The accepted ratio of the mass of the embryo “\( m_{\text{iz}} \)” to the mass of the seed coat of the peel of cotton seed “\( m_{\text{ik}} \)” presented as the fulfillment of the seed [16], affecting only the value of the mass of the seed should be considered from the point of view of the energy state of the seed “\( \mathcal{E}_{\text{vi}} \),” expressed as

\[
\mathcal{E}_{\text{vi}} = m_{\text{iz}} V_{\text{iz}} \gamma_{\text{iz}} \frac{V_{\text{ik}}}{m_{\text{ik}}},
\]

characterizing the share of the energy state of the seed embryo “\( \gamma_{\text{iz}}, V_{\text{iz}} \),” to overcome the resistance of the seed coat, manifested by its mass “\( m_{\text{ik}} \).”

All the indicated signs of the seed by the weight of the embryo “\( m_{\text{iz}} \),” seed coat peel “\( m_{\text{ik}} \),” and their density “\( \gamma_{\text{iz}}, \gamma_{\text{ik}} \)” with their corresponding volumetric dimensions “\( V_{\text{iz}}, V_{\text{ik}} \)” relative to the total weight of the seed “\( m_{\text{vi}} \)” and its total volumetric size “\( V_{\text{vi}} \)” characterize a stochastic state when each value of the mass attribute “\( m_{\text{vi}} \)” or its volumetric size “\( V_{\text{vi}} \)” the set of possible values of the above mentioned characteristics corresponds. Using individual averaged morphological signs of the stochastic state of the seed from the condition of establishing the general pattern of change in the mass of the seed “\( m_{\text{vi}} \)” and its high relationship with the volumetric size “\( V_{\text{vi}} \)” the closeness of their relationship with the establishment of statistical indicators for assessing the efficiency of using the mass of the seed is determined “\( m_{\text{vi}} \)” or its volumetric size “\( V_{\text{vi}} \).”

This makes it possible, according to the share of the energy state of the seed, attributable to overcoming the resistance of the seed coat (expression 4), to establish the specific energy indicator “\( \Delta \mathcal{E}_{\text{vi}} \),” characterizing its biological usefulness in each interval divided group of seed masses “\( m_{\text{vi}} \)” in their variation distribution, which has the form

\[
\Delta \mathcal{E}_{\text{v;i}} = \frac{m_{\text{iz}}}{m_{\text{ik}} V_{\text{vi}}} \text{ or } \Delta \mathcal{E}_{m_{\text{vi}}} = \frac{m_{\text{iz}}}{m_{\text{ik}} m_{\text{vi}}}
\]
depending on the efficiency of using the seed mass \( m_{c_i} \) or its volumetric size \( V_{c_i} \).

The alignment of a number of morphological features was carried out using the moving average method [5].

3. Research results and their discussion

Cotton seeds, as an object of research, are characterized by the presence of morphological components, reflecting the mass of the seed, with a tendency to change their values (Table 1).

In this case, the complex of morphological characteristics of seeds, as should be assumed, is a characteristic of the structure of the structure of the mass of the seed according to a single indicator of their values in the variational distribution, in the substantiation of which one should know the regularity of the change in the value of the mass of seeds.

The calculations of the data in Table 1 have established that the regularity of the distribution of seed masses obeys a normal law with statistical characteristics

\[ \bar{m} = 96.4 \text{ mg}, \quad \sigma = 18.15 \text{ mg}, \quad \sigma^2 = 329.573 \text{ mg}^2, \]

\[ V = 18.8 \% \] with evaluation criteria Pearson \( \chi^2 = 0.754 < \chi^2_{0.05} = 12.59 \% \), meaning that the differences between the actual and theoretical expected frequencies are insignificant and the null hypothesis about the correspondence of the empirical distribution to the theoretical one is not rejected, the results of which are graphically shown in Figure 1.

Embryo weight \( m_e \) and seed coat \( m_k \) (Table 1) with their corresponding density \( \gamma_{z_i}, \gamma_{k_i} \) (Table 2) in each interval divided group of seed masses \( m_{c_i} \) in their variational distribution are interconnected with the mass of the seed \( m_{c_i} \) and volumetric size \( V_{c_i} \).

Calculations to determine the tightness of communication \( m_e \), \( m_k \), \( \gamma_{z_i}, \gamma_{k_i} \) with mass \( m_{c_i} \) and its volumetric size \( V_{c_i} \) (Table 3) shows that the closeness of the relationship between the indicated morphological-physical characteristics with the total mass of the seed \( m_{c_i} \) and its volumetric size \( V_{c_i} \) are characterized by a high coefficient of correlation within \( r = 0.881 - 0.999 \) c error within

\[ S_r = 0.0169 - 0.178 \] with a significant excess of the actually obtained significance criteria \( t \) by Student \( (t_{0.05} = 5.0, t_{0.01} = 2.37, t_{0.001} = 3.5) \) and confidence intervals indicating the significance of correlation and regression at the 1st significance level. Comparison of indicators of regression coefficients \( b_c \) in the obtained regression equations for the relationship of morphological characteristics of seeds with its mass \( m_{c_i} \) and volumetric size \( V_c \) indicates the effectiveness of using the volumetric dimension \( V_c \) seed.
Figure 1. The distribution of the mass of seeds of the "m_i" variety An-Bayaut 2 and its delimitation by a number of racy hidden according to the mass of 1000 pieces determined in them and their energy indicators "∆Э".

Table 1. The results of the obtained data on the measurement of the morphological characteristics of the seeds of the An-Bayaut 2 variety

| Intervals of broken groups of seed masses, mg | Frequency P, % | Average weight of seeds m_i, mg | Embryo weight m_z, mg | Seed rind masses m_k, mg | Length a_i, mm | Width b_i, mm | Thickness c_i, mm | Lenght a_z, mm | Width b_z, mm | Thickness c_z, mm | Side part δ_δ, mm | Halaz part δ_δ, mm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| before 60 | | 42,6/50,3 | 13,4/19, 9 | 20,2/30, 4 | 8,1 | 4,5 | 3,8 | 7,54 | 4,02 | 3,320 | 0,24 | 0,28 |
| 61-70 | 1,6 | 65,8/61,8 | 32,9/32, 4 | 32,9/32, 4 | 8,4 | 4,6 | 4,0 | 7,84 | 4,11 | 3,512 | 0,24 | 0,28 |
| 71-80 | 12, 6 | 76,9/76,1 | 41,8/39, 6 | 35,1/36, 5 | 8,2 | 4,8 | 4,2 | 7,60 | 4,30 | 3,707 | 0,24 | 0,29 |
| 81-90 | 19, 0 | 85,7/86,2 | 44,2/47, 0 | 41,5/39, 2 | 9,0 | 5,0 | 4,3 | 8,40 | 4,50 | 3,802 | 0,24 | 0,30 |
| 91-100 | 20, 0 | 95,9/95,4 | 55,0/53, 2 | 40,9/42, 2 | 8,8 | 5,1 | 4,4 | 8,15 | 4,61 | 3,910 | 0,24 | 0,32 |
| 101-110 | 19, 4 | 104,5/105, 4 | 60,4/60, 4 | 44,1/44, 7 | 9,1 | 5,1 | 4,6 | 8,46 | 4,60 | 4,102 | 0,24 | 0,31 |
| 111-120 | 14, 0 | 115,1/114, 9 | 65,9/66, 4 | 49,2/48, 5 | 9,2 | 5,3 | 4,7 | 8,59 | 4,82 | 4,222 | 0,23 | 0,30 |
| 121-130 | 13, 3 | 125,0/124, 8 | 72,9/72, 1 | 52,1/52, 1 | 9,5 | 5,6 | 4,7 | 8,85 | 5,07 | 4,170 | 0,26 | 0,32 |
| 131-140 | 2, 9 | 134,7/131, 5 | 79,6/77, 4 | 55/54, 1 | 9,9 | 5,6 | 4,9 | 9,27 | 5,08 | 4,386 | 0,25 | 0,31 |

Note: the numerators are the actual, the denominator is the aligned figures
Table 2. Estimated indicators of the volumetric dimensions of the seed «$V_{c_i}$», embryo «$V_{z_i}$», seed coat peel «$V_{k_i}$», their density «$\gamma_c$, $\gamma_z$, $\gamma_k$» share of the energy state of seeds «$E_{c_i}$» and specific energy indicator «$\Delta \mathcal{E}_{c_i}$» per unit volumetric seed size in their variational distribution

| The interval of broken groups of seed masses | Volume size $V_i$, mm$^3$ | Density $\gamma_i$ mg/mm$^3$ | Indicator of the share of the expected energy state of the seed by the ratio of the embryo mass $m_z$ to the mass of the seed rind $m_k$ | Specific energy index per unit volumetric seed size $E_{c_i}$, c taking into account the mass $\Delta \mathcal{E}_{c_i} = \frac{\mathcal{E}_{c_i}}{V_{c_i}} \cdot 10^{-1}$ |
|---------------------------------------------|-----------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| before 60                                  | 72,0/75,1                  | 52,7/54,9                  | 19,3/20,3                                                                         | 0,255/0,355                                                                          | 0,459/0,720                                                                         | 0,637/0,917                                                                         |
| 61-70                                      |                            |                            | 22,2/21,4                                                                         | 0,555/0,490                                                                          | 1,485/1,511                                                                         | 1,000/0,869                                                                         | 1,229/1,045                                                                         |
| 71-80                                      |                            |                            | 22,8/23,8                                                                         | 0,659/0,601                                                                          | 1,538/1,530                                                                         | 0,891/0,847                                                                         | 1,191/1,056                                                                         | 1,380/1,181                                                                         |
| 81-90                                      |                            |                            | 26,3/25,2                                                                         | 0,588/0,654                                                                          | 1,568/1,551                                                                         | 0,843/0,887                                                                         | 1,065/1,182                                                                         | 1,047/1,214                                                                         |
| 91-100                                     |                            |                            | 26,4/26,9                                                                         | 0,715/0,675                                                                          | 1,548/1,571                                                                         | 0,928/0,904                                                                         | 1,345/1,270                                                                         | 1,325/1,212                                                                         |
| 101-110                                    |                            |                            | 83,6/84,0                                                                         | 0,723/0,719                                                                          | 1,597/1,626                                                                         | 0,940/0,943                                                                         | 1,370/1,327                                                                         | 1,214/1,174                                                                         |
| 111-120                                    |                            |                            | 111,7/111,6                                                                      | 27,6/27,5                                                                            | 0,723/0,719                                                                         | 1,597/1,626                                                                         | 0,940/0,943                                                                         | 1,370/1,327                                                                         | 1,214/1,174                                                                         |
| 121-130                                    |                            |                            | 119,9/120,7                                                                       | 28,4/29,5                                                                            | 0,720/0,729                                                                         | 1,734/1,643                                                                         | 0,960/0,953                                                                         | 1,339/1,372                                                                         | 1,117/1,136                                                                         |
| 130-140                                    |                            |                            | 130,5/130,8                                                                      | 0,745/0,734                                                                          | 1,599/1,635                                                                         | 0,958/0,956                                                                         | 1,399/1,398                                                                         | 1,072/1,078                                                                         | 1,017/1,046                                                                         |
Table 3. Statistical indicators of the correlation between morphological characteristics of seeds

| № | The name of the signs of the relationship of seeds | The type of manifestation of the regression equation for the relationship of seed traits | Correlation coefficient, \( r \) | Regression coefficient, \( b \) | Errors | Student's test of significance | Confidence interval at the 1\(^{\text{st}}\) level of significance |
|---|---|---|---|---|---|---|---|
| 1 | Influence of seed mass \(<m_c>\) on the: | | | | | | |
| | - embryo mass \(m_c= f(m)\) | | | | | | |
| | - seed coat weight \(m_c= f(m)\) | | | | | | |
| | - on the density of the embryo \(\gamma= f(m)\) | | | | | | |
| | - on the density of the seed coat \(\gamma= f(m)\) | | | | | | |
| 2 | Effect of volumetric seed size \(V_c\) on the: | | | | | | |
| | - per embryo weight \(m_c= f(V)\) | | | | | | |
| | - per seed coat weight \(m_c= f(V)\) | | | | | | |
| | - on the density of the embryo \(\gamma= f(V)\) | | | | | | |
| | - on the density of the seed coat \(\gamma= f(V)\) | | | | | | |

In particular, comparing the regression coefficients \(b^m_{m_i}\) and \(b^V_{m_i}\) in obtaining the mass of the embryo «
show that the efficiency of using the volumetric dimension «\( V_{c} \) » versus seed weight «\( m_{c} \) » increases by

\[
\Delta b_{m_{c}} = \frac{b_{m_{c}}^{V_{c}} - b_{m_{c}}^{m_{c}}}{b_{m_{c}}^{m_{c}}} \times 100 = \frac{0.8823 - 0.696}{0.696} \times 100 = 26.78\%
\]

(6)

Where \( b_{m_{c}}^{V_{c}} \) – regression coefficient of the linear equation of the embryo mass «\( m_{c} \)», derived from the influence of the volumetric size of the seed «\( V_{c} \)»;

\( b_{m_{c}}^{m_{c}} \) – regression coefficient of the linear equation of the embryo mass «\( m_{c} \)», obtained from the influence of the mass of the seed «\( m_{c} \)».

The density of the embryo changes accordingly «\( \gamma_{m_{c}} \)» on the

\[
\Delta b_{\gamma_{m_{c}}} = \frac{b_{\gamma_{m_{c}}}^{V_{c}} - b_{\gamma_{m_{c}}}^{m_{c}}}{b_{\gamma_{m_{c}}}^{m_{c}}} \times 100 = \frac{0.0053 - 0.00437}{0.00437} \times 100 = 21.28\%
\]

(7)

Where \( b_{\gamma_{m_{c}}}^{V_{c}} \) – the regression coefficient of the linear equation of the density of the embryo «\( \gamma_{m_{c}} \)», derived from the influence of the volumetric size of the seed «\( V_{c} \)»;

\( b_{\gamma_{m_{c}}}^{m_{c}} \) – the regression coefficient of the linear equation of the density of the embryo «\( \gamma_{m_{c}} \)», derived from the influence of the mass of the seed «\( m_{c} \)».

In terms of comparing the regression coefficient of the linear equation in obtaining the mass of the seed coat «\( m_{k} \)» efficient use of volumetric semen «\( V_{c} \)» relative to the weight of the seed «\( m_{c} \)» increases by

\[
\Delta b_{m_{k}} = \frac{b_{m_{k}}^{V_{c}} - b_{m_{k}}^{m_{c}}}{b_{m_{k}}^{m_{c}}} \times 100 = \frac{0.3807 - 0.299}{0.239} \times 100 = 27.3\%
\]

(8)

Accordingly, the density of the seed coat increases «\( \gamma_{k} \)» on the

\[
\Delta b_{\gamma_{k}} = \frac{b_{\gamma_{k}}^{V_{c}} - b_{\gamma_{k}}^{m_{c}}}{b_{\gamma_{k}}^{m_{c}}} \times 100 = \frac{0.00248 - 0.00198}{0.00198} \times 100 = 25.3\%
\]

(9)

The difference in expression (6) and (8), equal to 27.3÷26.78=0.52 %, gives reason to believe about the increase in the mass of the seed coat of the shell relative to the mass of the shell of the seed coat, depending on the size of their size, manifested by an increase in the thickness of the seed coat «\( \delta_{c} \)» a corresponding change in the volumetric size of both the seed and its seed coat.

The difference in expressions (7) and (9), equal to 25.3÷21.28=4.02 %, means increased density of the seed coat "\( \gamma_{k} \)" relative to the density of the embryo "\( \gamma_{m_{c}} \)”, creating a higher resistance of the seed coat, to overcome which more energy is spent for the emergence of the seedling.

By the efficiency of using the volumetric size of the seed "\( V_{c} \)" versus seed weight "\( m_{c} \)”, revealed when comparing the indicators of the regression coefficients in the obtained equations (table 3), conditions
are created in the calculated determination of the specific energy indicator «ΔЭ» (expression 5) in each interval divided group of seed masses in their variational distribution.

Specific energy index «ΔЭ»c» per unit volumetric dimension of each seed “Vc”, depending on the mass of the seed in physical essence, it characterizes the biological usefulness of the seed in the implementation of the release of seedlings from the inner cavity of the seed to the outside of its surface in the presence of moisture and temperature both in laboratory and in production conditions.

Calculated values of the specific energy index «ΔЭ»c» depending on the size of the seed mass “m_c”, are manifested by a curvilinear dependence (table 2).

Statistical processing of data on the relationship between the value of the mass of the seed “m_c”, (table 1) with calculated values of specific energy indicators «E» (table 2) showed that the biological usefulness of seeds in terms of the tightness of the connection is manifested by a curvilinear dependence in the form of a quadratic parabola (Fig. 2), determined by the expression

$$\Delta \mathcal{E} = -0.161435 + 0.0281716m_c - 0.0001443m_c^2$$  \tag{10}

with correlation ratio $\eta_{m_c, \Delta \mathcal{E}} = 0.932$, a mistake $S_\eta = 0.137$ and exceeding the actually obtained Student’s criterion $t_\phi = 6.8$ over theoretical $t_{0.05} = 2.37, t_{0.01} = 3.5$ at the 1m level of significance ($t_\phi > t_{0.05} > t_{0.01}$).

The use of Fisher’s criterion "F" in determining the degree of approximation of a curvilinear dependence to a rectilinear one calculated by the formula [5]

$$F_\phi = \left(\frac{\eta^2 - r^2}{n - K}\right) \frac{(n - K)(n - 2)}{1 - \eta^2} \tag{11}$$

Where $\eta^2$ – correlation ratio squared;
$r^2$ – squared linear correlation coefficient;
$n$ – sample size;
$K_x$ – number of groups for a number of seed masses

made up $F_\phi = \frac{(0.86858 - 0.2926^2)(9 - 4)}{(1 - 0.86858)(4 - 2)} = 14.89$

then, as the theoretical values were $F_{0.05} = 3.1, F_{0.01} = 4.86$ at degree of freedom $\nu_1 = K_x = 2 = 4 - 2 = 2, \nu_2 = n - 2 = 100 - 2 = 98$.

When $F_\phi > F_{0.01}$ nonlinearity is significant at the 1m level of significance.

The derivative of expression (10) in determining the specific energy index «ΔЭ»c», characterizing the value of the indicator of the biological usefulness of the seed, with its maximum value equal to $\Delta \mathcal{E}_{om} = 1.2135 - \frac{1}{Mm}$ corresponds to the optimal value of the seed mass $m_{om} = 97.6$ mg, which is practically equal to the average mass corresponding to the maximum of the curve of the variational distribution of the seed masses of the initial material equal to $m = 96.4$ mg when recalculated for 100 pieces of seeds. The nominal deviation of their values within 1.2% is explained by the rounding of the data obtained.
This gives reason to believe that biologically high-energy index are concentrated in the middle of the variational distribution of their masses in the initial seed of the An-Bayaut 2 variety under consideration with a mass of 1000 pieces $m_{1000}=96.4$ mg.

The symmetry of the left and right branches of the curve of the normal distribution of seed masses (Figura 1) makes it possible, by drawing a number of dissecting straight lines, to delimit the curve with the release of different volumes of seeds in its middle part and to determine the effect of the volume of their output on the average value as an indicator of the mass of seeds «$m_i$» and their specific energy indicator «$ΔЭ$» with their statistical characteristics (table 4).

**Table 4.** Influence of the volume of allocation of the middle part of the curve of the variational distribution of seed masses on the average weight «$m$» and specific energy index and their statistical characteristics

| The volume of the selected middle part of the curve of the variational distribution of seed masses $p$, % | The limit of change in the values of the masses of seeds $Δm$, mg | Average mass of seeds in volumes of the selected middle part of the curve of variational distribution of mass of seeds $m_{Vm}$, mg | Average specific energy index in the volumes of the selected middle part of the variational distribution of seed masses $ΔЭ = \frac{m_i}{m_{Vm} V_m}$, $1_{mm^3}$ | Statistical characteristics of the middle part of the delimited volume of seeds in the curve of the variational distribution of their masses | Mass standard deviation $S_m$, mg | Mistake $S_m V_m$, % | Standard deviation in specific energy index $SΔЭ$, $\frac{1}{MM^3}$ | Mistake $S_{ΔЭ} V_{ΔЭ}$, % | Coefficient of variation for specific energy index $\DeltaЭ V_{ΔЭ}$, % |
|---|---|---|---|---|---|---|---|---|---|
| 100. | 50.3-131. | 96.37/96.5 | 1.1729 | 17.62 | 1.762 | 0.05923 | 0.0059 | 18.26 | 5.05 |
| 94.4 | 50.3-131. | 96.77/96.6 | 1.1828 | 15.45 | 1.59 | 0.04125 | 0.0042 | 16.93 | 3.08 |
| 5 | 62.5-130. | 1.1871 | 7 | 1.517 | 0.03543 | 0.0042 | 14.93 | 2.99 |
| 90.7 | 130. | 1.1922 | 14.45 | 1.427 | 0.02581 | 0.0031 | 13.37 | 2.17 |
| 9 | 0 | 1.2067 | 7 | 1.061 | 0.00925 | 0.0031 | 12.08 | 2.17 |
| 86.8 | 65.9-124. | 1.2094 | 13.29 | 1.017 | 0.00627 | 8 | 7.04 | 0.52 |
| 59.0 | 126. | 124. | 0 | 124. | 0 | 124. | 0 | 124. | 0 |
| 81.5 | 111. | 85.0-107. | 95.56/96.6 | 17.62 | 1.762 | 0.05923 | 0.0059 | 18.26 | 5.05 |

Note: the numerators are actually data, and the denominator is aligned
It was found that the tightness of the relationship between the mass of seeds «$m_i$», with the volume of their output «$P_i$» from the middle part of the curve of the variational distribution of seed masses is manifested by a curvilinear dependence in the form

$$m_i = 94.85 + 0.0525956P_i - 0.000342143P_i^2$$

(12)

and with the correlation ratio $\eta_{P_i m_i} = 0.904$ on error $S_\eta = 0.214$ the criterion of significance according to the Student was obtained $t_\eta = 4.224$, exceeding theoretical $t_{0.05} = 2.78$ at $V = n - 2 = 6 - 2 = 4$

$t_{he} = 2.78$.

The derivative of expression (12) characterizes the limit of the use of the volume of seed yield for use for sowing. The limit of using the output volume of the middle part of the curve of the variational distribution of seed masses for the considered cotton variety "An-Bayaut 2" with a mass of 1000 pcs, equal to $m_{1000} = 96.4$ g is an $P=76.8$ % with an average mass equal to $\bar{m} = 96.87$ mg within delimited seed masses $m_{op} = 74.5$ mg, $m_{ap} = 118.5$ mg (Figura 2).

The tightness of the connection of the specific energy indicator “$\Delta \mathcal{E}$”, seeds with the output volume of the middle part of the curve of the variational distribution of seed masses “$P_i$” with approaching the maximum, its curve manifests itself as a linear correlation dependence in the form

$$\Delta \mathcal{E} = 1.2404 - 0.0006124 P_i$$

(13)

with correlation coefficient $r_{\Delta \mathcal{E} P_i} = 0.961$ and his mistake $S_r = 0.138$ the actual Student's test was $t_r = 6.93$, and theoretical $t_{0.05} = 4.6$ at $V = n - 2 = 6 - 2 = 4$. In conditions $t_r > t_{0.01}$ means that correlation and regression are significant at the 1% level of significance.

With a decrease in the output volume in the middle of the curve of the variational distribution of seed masses, with approaching the maximum of the curve, the value of the specific energy index increases “$\Delta \mathcal{E}$”, which gives reason to believe that biologically valuable seeds are concentrated in the middle part of the variational distribution of seed masses, i.e. the value of the mass of seeds when indirectly displaying their energy state is a single sign in setting the limit for the use of their values for sowing, taking into account their potential capabilities. A decrease in the volume of seed yield "P" from the middle part of the curve of the variational distribution of seed masses is accompanied by a high uniformity of seeds in accordance with their calculated statistical characteristics (Table 4), which showed a stable indicator of their sowing qualities in terms of the difference in germination energy (HCP05 = 2.095%) and germination (HCP05 = 2.095%) in comparison with the initial ones according to the difference in their average values for germination energy within 5-6%, and for germination within 2.5-4.0% (table 5).

High difference in germination energy between the delimited volume of the middle part of the variation distribution of seed masses, selected according to the specific energy indicator “$\Delta \mathcal{E} = \frac{m_i}{m_i V_c}$”, per unit volumetric size “$V_c$” as the most effective in comparison with the mass “$m_c$” seed by the value of the regression coefficient and the initial is explained by the fact that additional conditions arise during sowing, manifested by a high rate of swelling of the volume of the seed and the speed of its closure than with an increase in the mass of the seed [13].

In this regard, the joint use of the selection of the specific energy indicator “$\Delta \mathcal{E}$” per unit size “$V_c$” seed and the accelerated completion of the completion of the swelling of the volume of the seed in comparison with the mass characterizes the physical essence of the completeness of the manifestation of the biological
usefulness of seeds in ensuring the simultaneity of germination and earlier ripening of cotton.

**Table 5.** Influence of the secretion of the volume of seeds with the corresponding specific energy index «$\Delta \varepsilon_i$» for sowing quality of seeds cotton varieties "An-Bayaut 2"

| Name options                                | Output, % | Specific energy index per unit volumetric seed size | Estimated uniformity and standard deviation | Germination energy, % I II III cp. | Seed germination, % I II III cp. |
|---------------------------------------------|-----------|------------------------------------------------------|--------------------------------------------|-----------------------------------|---------------------------------|
| Seed mass range - initial 50,3-131,5 mg     | 100       | 1,1729                                               |                                             | 18,6                              | 82 85 86 84 93 94 96 94,5       |
| The middle part of the curve of the variation distribution of seed masses 65,9-125 mg | 90,80     | 1,1871                                               |                                             | 14,5                              | 88 89 90 89 96 97 99 97         |
| 70-124 mg                                   | 86,7      | 1,1922                                               |                                             | 13,3                              | 90 91 89 90 97 99 99 98,5       |
|                                             |           |                                                      | Estimated uniformity and standard deviation | 90 91 89 90 97 99 99 98,5         |
|                                             |           |                                                      |                                             | HCP<sub>05</sub>=2,095             |                                |
|                                             |           |                                                      |                                             | HCP<sub>05</sub>=2,27              |                                |

Note: Initial seeds prepared for sowing in factory conditions.

So the mass of the seed "$m_c$" in relation to the volume of output «$P$» from the middle part of the curve of their variational distribution determines the establishment of the optimal yield of sowing seeds from a quantitative point of view, and in conjunction with the specific energy index (Figure 2) reveals the qualitative indicators of sowing seeds with approaching the maximum of the curve of the variation distribution of seed masses. This makes it possible, according to the specifying parameters of the seed masses, corresponding to the optimal volume of seed yield, to assess their quality from the point of view of their biological usefulness for use for sowing.

![Figure 2](https://via.placeholder.com/150)

**Figure 2.** Dependence of the specific energy index "$\Delta \varepsilon$" on the value of the mass of seeds "$m_t$" in their variational distribution
4. Findings
1. The stochastic presence of morphological characteristics of cotton seeds according to the composition of a complex set of their values is subdivided into increasing indices of the mass of the embryo and the mass of the seed coat;
2. The density of the embryo, manifested by the degree of concentration in it of the chemical composition of accumulated nutrients in conditions of swelling, characterizes the energy state of the entire seed, and the density of the seed coat of the peel shows resistance to the emergence of the seedling;
3. The value of the ratio of the mass of the embryo and the mass of the seed coat of the peel increases with an increase in the mass of the cotton seed, and according to the specific energy index per unit of the volumetric size of the seed, according to the tightness of the relationship with the value of the seed mass, characterizes the regularity of the change in the biological usefulness of seeds by the concentration of their high indicators in the middle parts in the variational distribution of their masses.
4. The mass of the seed is a single feature in the structure of its structure to determine and substantiate the physical essence of the use of the middle part of the curve of the variational distribution of the masses of seeds according to the parameters specifying them with the establishment of an estimated energy indicator in ensuring the uniformity of obtaining seed with high sowing qualities.

5. Conclusion
The mass of cotton seeds in the original sowing material is characterized by the variational distribution of their masses. It has been established that the specific energy index of the seed in relation to its mass reveals the physical essence of the biological usefulness of seeds, the regularity of the change in which in curvature coincides with the manifestation of the curve of the normal distribution of their masses. With an increase in the size of the seeds, the density of the seed coat increases and, accordingly, its mass. In this regard, the separation (isolation) by the mass of seeds is accompanied by the presence of less biological usefulness of seeds, delaying the process of emergence of seedlings and their development with a decrease in cotton productivity. The specific energy index per unit of the volumetric size of the seed in terms of the efficiency of its use in comparison with the mass of the seed, when sowing due to accelerated completion in obtaining the swelling limit of the volumetric size in comparison with the change in the value of its mass in terms of the simultaneity of the emergence of seedlings and the rate of their development of seedlings creates an additional condition in the completeness of the manifestation of the biological usefulness of seeds.

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