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Research Article

On The Closed Trajectory of Movement of Biological Time Inside the Organism of a Plant in Ontogenesis and Everything Secret Becomes Apparent

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Annotation

The work considers a separate biological time in plant ontogenesis. Based on the proven method of degree - days, the sum of scalar products of two-time vectors of biological time is built. Further, a curvilinear integral of the second kind is found as a replacement for the degree-day's method. An open curvilinear integral only shows the assumptions about the properties of time inside the plant organism. A closed curvilinear integral of the second kind fully proves the assumption made: time inside the plant's organism is closed. The conclusion is made about the existence of a temporary surface inside the plant organism. Biological time is compared with the influence on the movement of chromosomal material inside the cell. It turns out that the chromosome is completely subordinated to biological time, or simply time. All calculations are based on the material processes of photosynthesis, respiration, plant growth in ontogenesis.

Introduction

In this work, we will consider time. We can consider time only by the totality of material processes that occur inside the plant's organism. We will distinguish between biological and physical time. Biological time has the property, inside the plant organism, to stretch or shrink depending on the weather, from the state of agrometeorological factors (this was established by Reaumur in the XVIIIth century). So, it has long been established that the rate of development of a plant organism depends primarily on the ambient temperature [1]. Subsequently, practical data were obtained that indicate that the rate of development of plants depends on such agrometeorological factors as their state at the current moment of growth and development: light - the arrival of FAR [2,3,4] moisture - reserves of productive moisture in the soil [2,3] nutrition - mineral nutrition in the soil-NPK [5]. These factors, together with the properties of physical time and our three-dimensional physical space, are the basic component of a plant's organism for life. In this work, we will show, at least, that the biological time of a plant moves along a closed trajectory and determines the growth of dry biomass of the plant's general organism.

Materials and research methods

Change in biological time on a straight time axis

We will assume that there is its own biological time inside the plant organism. As soon as we assumed this, we immediately receive in response a method for calculating this biological time of a plant: this method consists in the fact that for each day of ontogenesis, the relative values of the increments of dry biomass of the whole organism of an annual plant and changes in the increment of biological time under different agrometeorological factors are compared, and the same moment of ontogenesis [6]. I have shown that the calculation of the biological time of a one-year plant organism until the moment of the "flowering" phase can be obtained by the equation $T(j+1) = T_0 + T(j) + \Delta T_{opt}\Omega(j)$ $, T_0 < T(j) < 0,5,$ (1) where T_0 - the initial value of the biological time corresponding to the "shoots "phase of an agricultural crop (or simply a plant), relative units; T(j) - is the current value of the biological time of the whole plant organism for the lived day j, relative units; ΔT_{opt} - is the increase in biological time for one calculated day of plant growth and development with optimal agrometeorological factors, relative units; Ω (j) - the normalized value of CO_2 gas exchange in the whole plant organism, which is the value of CO_2 gas exchange at low agrometeorological factors, divided by the amount of CO_2 gas exchange at optimal agrometeorological factors of the whole plant organism as a whole in one calculated day, relative units. The "flowering" phase itself determines new essential physiological properties in the plant. After "flowering" changes occur in the growth and development of the plant. So, in sunflower and other crops, the growth of leaves, stems, petioles, and roots stops. At the same time, after the flowering of the sunflower, the processes of dying off all vegetative organs begin to occur and only the generative organs continue their growth and development. When the vegetative organs die off, part of the biologically active substance from the vegetative organ is sent to the generative organs - the basket and seeds, the rest of the vegetative organs simply ends their growth and development. Therefore, the calculation of the biological time of a plant changes significantly after the "flowering" phase [6]. Thus, after the "flowering" phase, before the "maturation" phase, the calculation of the biological time can be carried out according to the equation $T(j+1) = T(j) + \frac{\Delta T_{opt}}{\Omega(j)}, \quad 0,5 < T(j) < 1.$ (2) In the calculated equations (1) and (2) the total biological time of the whole plant organism moves from the value of small T_0, corresponding to the vegetative phase of "shoots" to the value of T(j)=0.5, corresponding to the vegetative phase of "flowering", and continues its movement until values of T(j)=1, corresponding to the vegetative phase "maturation". Thus, for the entire vegetation period "shoots -maturation" biological time corresponds to one biological unit of time under any agrometeorological conditions of plant life. If before the vegetative phase "flowering", with a decrease in temperature, moisture, FAR, mineral nutrition, etc. (all agrometeorological factors) the development of the plant slows down, then after the vegetative phase "flowering", with a decrease in agrometeorological factors, the development of the plant is accelerated. This property is inherent in many agricultural crops [7,8].

These two equations (1) and (2), allow calculating and making predictions of the onset of flowering and full maturation phases, depending on the current agrometeorological factors, as a simple sum for each day of plant life on an accrual basis. Other phases of plant development can be found as additional biological times for each phase of plant development. At the same time, these values of biological time will be located only in the middle of the interval from T_0 to 1. (For sunflower, these may be the following additional vegetative phases: "real third leaf", "budding", "milk ripeness", "wax ripeness", for other crops, other corresponding vegetative phases of development). For such a calculation, for the implementation of the forecast, before the date of the forecasts, real data are taken on the agrometeorological factor that already existed during the life of the plants. And the missing future agrometeorological factors can be taken as mean long-term values, or, according to long-term meteorological forecasts. As soon as the required number of biological times has come, the calculations are stopped. The value of the correction Ω (j) of the optimal value of the increase in biological time for the current state of agrometeorological factors, in the first approximation for sunflower, can be calculated as a simple product of the normalized value of the light curve of photosynthesis [9,10] the normalized temperature curve of photosynthesis [10] the normalized wet curve moistness soil influence of photosynthesis [11] the normalized curve of the mineral nutrition of plants [12]. All normalizations of the curves are given by me according to the corresponding curves from their maximum value. The normalized lights curve of sunflower for the FAR flow is as follows $I(j) = 1 - \exp\left[-CI_{opt}I_n(j)\right]$, (3) where I(j) - is the normalized value of the lights curve influence of sunflower photosynthesis, relative units, varies from 0 to 1, it is assumed that the exponent has its maximum; C - parameter, $m^2 \cdot W^{-1}$; Iopt - is the value of the FAR flux at which the maximum intensity of photosynthesis is observed, $W \cdot m^2$; I_n(j) - the normalized value of the real FAR flux coming to the upper sowing border, is found as the current FAR flux value divided by the FAR flux value in a cloudless sky, relative units. The temperature curve for the influence the intensity of the photosynthesis process has the form $\psi(j) = 1 - a_t t^2_{opt}\left[t_n(j) - 1\right]^2$ (4) where ψ (j) - is the current normalized value of the temperature curve of the intensity of the photosynthesis process, varies from 0 to 1, relative units; α_t - parameter, $(C^0)^{-2}$; t_{opt} - is the optimum air temperature for the intensity of the photosynthesis process, C°; t_n(j) - the current normalized value of the air temperature inside the crop, relative units, is found as the value of the air temperature divided by the temperature at which the maximum intensity of the photosynthesis process is observed. The soil moisture curve of the intensity of the sunflower photosynthesis process has the form $\gamma(j) = 1 - a_w W^2_{opt}\left[W_n(j) - 1\right]^2$ (5) where γ (j) - is the current normalized value for the intensity of the photosynthesis process, varies from 0 to 1, relative units; α_W - parameter, mm^{-2}; W_{opt} - optimal reserves of productive moisture for the process of photosynthesis, in the soil layer 0-100 cm, mm; $W_n(j)$ - normalized values of productive moisture in the soil layer 0-100 cm, relative units, is found as the current reserves of productive moisture in the soil divided by the optimal reserves of productive moisture in the soil. It remains to find the magnitude of the influence of each active substance stocks of mineral nutrition to change the CO_2 - gas exchange whole plant body, or it impact on the rate of photosynthesis process. To do this, we will use several equations obtained by me in the calculations [12] which represent one whole and such a calculation of the effect of mineral fertilizers on the development process is performed once before the "shoots" phase or on the date of fertilization. So, first, we calculate the maximum yield of the total dry biomass, where the subscript k denotes the choice of nitrogen N, phosphorus P or potassium K as the active ingredient of the fertilizer $X_{K\max} = \frac{k_k^p}{k_k^u}\left(S_k^o - S_k\right)$ (6) where X_{kmax} - is the maximum dose of fertilizers at which the highest yield can be obtained, kg of active *ingredient per hectare*; S^0_k - the optimal value of the k-th (k belongs to N, P or K) nutrient content in the root layer of the soil (usually they take a soil layer of 0-20 cm), kg of active substance per hectare; S_k - the value of the content of the k-th nutrient in the root layer of the soil before fertilization, kg of active substance per hectare; k^p_k - is the utilization factor of the k-th nutrient from the fertilizer, rel. units. In the future, we need to calculate the value of the yield of all dry biomass plant depending on the value of the applied fertilizer dose X_k according to the equation

$$Y_{NPK} = \frac{4C_{K\max}}{S_k^o.k_k^p}\left[\begin{array}{l} -\frac{1}{3}\left(k_k^u\right)^2.X_k^3 + \left(\frac{1}{2}k_k^u.k_k^p.S_k^0 - k_k^u.k_k^p.S_k\right).X_k^2 + \\ +\left(k_k^p.k_k^p.S_k^0.S_k - \left(k_k^p.S_k\right)^2\right).X_k \end{array}\right] + \frac{k_k^p.S_k}{k_k}$$

(6.1) where Y_{NPK} - the value of the total yield of dry biomass of a plant, depending on the applied dose of fertilizer, 100·kg·ha-1; C_{kmax} - constant, parameter, rate of increase in total dry biomass depending on the unit of increment of the fertilizer dose $\Delta Y_{max} \cdot \Delta X_k^{-1} = C_{kmax}$, $kg \cdot kg^{-1}$; k_k - is the content of the k-th nutrient per unit all dry biomass of the gathering in of the crop, rel. units. Such a calculation, according to equation (6.1) the value of dry biomass will not be accurate, since the crop yield depends on the prevailing agrometeorological conditions of plant life. To exclude this property of equation (6.1) it is necessary to make another calculation of the value of the total dry biomass of the crop according to equation (6.1) but at the value of the maximum fertilizer dose, which was obtained earlier according to equation (6). Finally, the effect of the applied dose of fertilizer on the rate of growth and development of the crop[12] can be obtained as the ratio of the yield value, taking into account the applied dose of fertilizer Y_{NPK}, obtained according to equation (6.1) to the value of the maximum yield Y_{NPKmax}, obtained from equation (6.1) according to the equation $\alpha_k(1) = \frac{Y_{NPK}(1)}{Y_{NPK\max}}$ (6.2) Then all three obtained values: $\alpha_N(1), \alpha_P(1), \alpha_K(1)$ for three active substances N, P or K of mineral fertilizers will vary from 0 to 1, at the same time showing a decrease in yield and a change in speed development with a large dose of fertilizer. (Figure1) shows the calculations according to the equation (6.1). Now are all ready to obtain a correction for the value of value of the optimal increase in biological time Δt_{opt}, depending on the current state of agrometeorological factors Ω (j) in equations (1) and (2), in the first approximation $\Omega(j) = I(j)\psi(j)\gamma(j)\alpha_N(1)\alpha_P(1)\alpha_K(1)$ (7).

Results of calculating biological time on a straight time axis

The onset of phenological phases of flowering and maturation of sunflower for years different in agrometeorological conditions are given in (Table 1). As can be seen from (Table 1), the dates of the onset of vegetative phases of development almost completely coincide with the calculated data. The difference in the duration of the between-phase periods can be ensured by the accuracy of the calculations and by the fact that several agrometeorological stations were taken for the dates of the onset of the "flowering" and "maturation" phases. In total, 7 agrometeorological stations located on the territory of the Odessa region were processed for calculations. (Table 1). As can be seen from the data obtained in the calculations of the phase "flowering" of sunflower occurs on average 63 days after "shoots". At the same time, these 63 days correspond to the value of the biological time axis equal to 0.5 relative unit's timeline. The "maturation" phase on average, in the calculations, is 103 days from the "shoots", which is a fairly accurate calculation, and the value of the biological time axis is 1.0 relative units. It should also be noted that the calculation equations (1) and (2) use the same value of the optimal increase in biological time Δt_{opt}, both before "flowering" and after "flowering". This means that the biological time moves inside the plant organism unambiguously, both before flowering and after flowering and is determined only agrometeorological factors of life. So, we got that over biological time varies depending on the weather changes, agrometeorological conditions depending on changes in gas exchange of CO_2 the whole body of the plant. At the same time, the calculation is carried out for one day of plant growth for the entire ontogenesis. For each culture or crops variety is its value of quantity ΔT_{opt}.

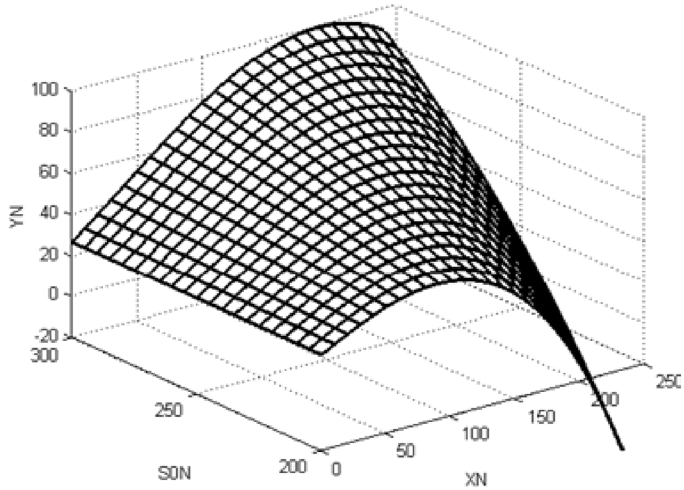


Figure 1: Influence of different doses of nitrogen N and different doses of the optimal value of nitrogen content N in the soil, as an active substance, on the yield of dry total biomass of winter wheat: YN - yield of total dry biomass, 100·kg·hectare-1. XN - is the value of the applied nitrogen dose, kg active substance·hectare-1. S0N - different values of the optimal nitrogen content in the topsoil 0-20 cm, kg active substance·hectare-1.

units of measurement - YN, kg·ha^{-1}

Table 1: Comparison of the calculated and actual dates of the onset of the phenological phases of sunflower development for different years on average for the whole Odessa region (actual data obtained by the Hydrometeorological Service of Ukraine).

Observation year	Between the phase period "shoots" -"flowering", day		"flowering", day Between the phase period "shoots" -"maturation", day	
	Factual data	Estimated data	Factual data	Estimated data
1992	70	72	93	109
1993	67	63	101	100
1994	58	67	100	103
1995	62	61	104	105
1996	58	59	99	93
1997	58	61	96	107
1998	65	63	97	113
1999	64	62	97	96
the average	63	63	98	103

Biological time as an unclosed curvilinear integral of the second kind

It should be noted the following fact of the already proven change in the movement of biological time calculated by equations (1) and (2). So, if we consider changes in the increments of biological time, then this increment becomes depending on agrometeorological conditions on each day of plant growth and development. This means that we can assume that the vector of the maximum in biological time ΔT_{opt} deviates from its direction in the plant. And we can think of the modified vector ΔT as the dot product of two vectors. In this case, as we believe, the deviation of the vector ΔT_{opt} occurs from the axis of physical time, which flows in its own way. Then the projection of the deflected vector ΔT_{opt} onto the direction of the physical time axis will give the values of the vector ΔT. That is, we can consider the scalar product of two vectors: 1. The vector ΔT_{opt}, deviated from the physical axis of time t, and 2. The vector ΔT_{opt} lying on the axis of physical time t. Thus, we follow the fact that during the life of a plant, we need to find the sum of the scalar products of two vectors of the biological time of the plant according to equations (1) and (2). Such a calculation was made, and we can see the change in the biological time axis in relation to the change in the physical time axis in (Figure 2). As can be seen from (Figure 2) biological time is significantly changed in relation to physical time. At the same time, it is necessary to immediately note the following fact: we consider the scalar product of two vectors, then the first vector can deviate from the physical axis of time only in the two-dimensional time space inside the plant organism. For further calculations, we need to make some assumptions: we will consider the fact that in the whole ontogeny of a plant, the process of photosynthesis and the process of respiration change from day to day, smoothly. That is, they are smooth curves. The same can be said for the two-time axes - they are smooth curves. Then we can proceed to consider our phenomenon in a differential form.

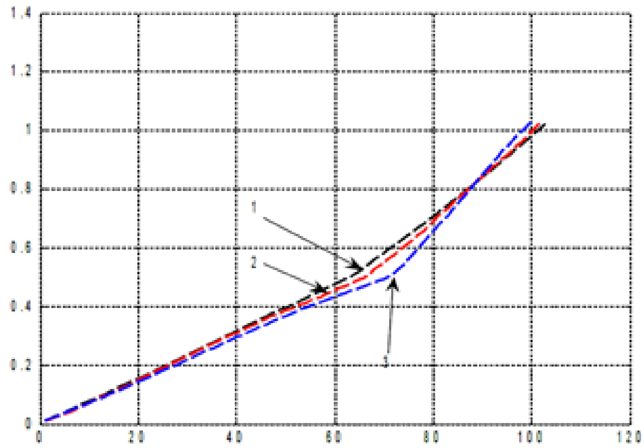


Figure 2: Change in the flow of biological time in relation to physical time, Odessa, settlement “Chernomorka»: 1 - average long-term values of agrometeorological factors;2 - agrometeorological factors of 1986 of the year; 3 - agrometeorological factors of 1987 of the year.

units of measurement – T(j), relative units

Then, the growth of the total dry biomass of the whole plant organism follows a smooth S - shaped curve. To begin this consideration, we write down an open curvilinear integral of the second kind, which fully corresponds to equations (1) and (2). $T(j)=\int_{t_0}^{t_E}\left(P\frac{dT_F(j)}{dt}+Q\frac{dt_R(j)}{dt}\right)dt$,(8) here T(j) - is the summed axis of the biological time of an annual plant; P -some function; - rate of change of the first axis of biological time; Q - some function; - the rate of change of the second axis of biological time; t0- initial integration physical time, corresponds to the “shoots” phase; t_E - the final integration physical time, corresponds to the “maturation” vegetative phase; t - is physical time. In equation (8) it immediately follows that we are considering the process of biological time of a plant already in two-dimensional time space. This also follows from equations (1) and (2). It is advisable when considering equation (8) to use the material processes of photosynthesis, respiration, growth rate. Let us now consider the fundamental equation for the growth of the total dry biomass of a plant, obtained by [14] of the year. $\frac{dM_{dm}}{dt}=\frac{dF_{dm}}{dt}-\frac{dR_{dm}}{dt}$ ’ (9) where dM_{dm}/dt - is the growth rate of the total dry biomass of the whole plant, g_{dm}·days-1; dF_{dm}/dt - process (rate) of photosynthesis of the whole plant organism expressed in dry biomass, gdm·days-1; dR_{dm}/dt - the process (rate) of respiration of the whole plant organism, the costs of the respiration process are also expressed in dry biomass, gdm·days-1; dt - is the differential of physical time, in the case of this equation it is one day. This equation shows that the increase in the total dry biomass of the whole plant organism is determined by the rate of CO_2 gas exchange of the entire plant. For a practical view of the increments in the total dry biomass of potatoes during the entire ontogenesis, see (Figure3). Also, this (Figure 3) gives direct views on the magnitude of the change in the process of photosynthesis and the process of respiration in plant ontogenesis according to equation (9). In addition, as can be seen from (Figure 3), for each year of observation there is its own, different, maximum growth rate of the total dry potato biomass. This is ensured by years of different weather conditions. dM/dt, $g_{dm}\cdot m^{-2}\cdot days^{-1}$ physical time, day from “shoots”. To compare the integrand of equation (8) with the equation for the increase in total dry biomass (9) we need to find the normalized values of the increase in total dry biomass during ontogenesis. This must be done because the biological time of a plant is also expressed in relative units. To do this, consider the sigmoid curve of plant growth, (Figure 4), and normalize it to the value of the final total dry biomass of the whole plant organism. In this case, the sigmoid curve grows of the plant will change from some small μ_0 , corresponding to the «shoots» phase, to one. Corresponding to the “maturation” phase, and in years different in weather conditions will have almost the same appearance, depending on in the movements of the biological time of the plant. Then we can write

$$\frac{dM_{dm}}{M_{\max}dt}=\frac{dF_{dm}}{M_{\max}dt}-\frac{dR_{dm}}{M_{\max}dt}=\frac{dM_{\mu dm}}{dt}=\frac{dF_{\mu dm}}{dt}-\frac{dR_{\mu dm}}{dt} ,$$

(10) where M_{max} - is the value of the total dry biomass of the whole plant organism for the “maturation” phase, this is the maximum value of the total dry biomass of the plant, g_{dm}; $dM_{\mu dm}$ - is the normalized value of the increments (differential) of the total dry biomass of the whole plant organism, relative units·day-1; $dF_{\mu dm}$ - normalized value of increments (differential) of total dry biomass in the process of photosynthesis, relative units·day-1; $dR_{\mu dm}$ - is the normalized value (differential) of the costs for the respiration process of the whole

plant organism, relative units·day-1. Now we can compare equation (8) - its integrand, with the equation of Davidson J.L. and Philip J.R. (10). $P\frac{dT_F(j)}{dt} = \frac{dF_{\mu dm}(j)}{dt}$, (11) $-Q\frac{dT_R(j)}{dt} = \frac{dR_{\mu dm}(j)}{dt}$. (11.1) From this the two vector functions P and Q have relative units in their dimension. The value of these two vector functions P and Q can be a value equal to one. Then the rate of flow of biological time in relation to physical time for the processes of photosynthesis and the process of respiration will be different. So, the speed of movement of biological time for the process of photosynthesis will be completely positive, and for the process of plant respiration - negative. This conclusion, moreover, follows from the fact that in the process of photosynthesis there is a positive increment of new biomass substance, and in the process of plant respiration, the created biomass is consumed from the plant organism and energy is generated for growth. Thus, in the process of plant respiration, biological time (or simply time) moves backward. Let us now write down the complete non-closed curvilinear integral of the second kind for calculating the processes of the flow of biological time inside a plant. $T(j) = \int_{t_0}^{t_E} \left[\frac{dF_{\mu dm}(j)}{dt} + \left(\frac{-dR_{\mu dm}(j)}{dt}\right)\right]dt$ or

(12) $T(j) = \int_{t_0}^{t_E} \left[\frac{dT_F(j)}{dt} - \frac{dT_R(j)}{dt}\right]dt$, (12.1) where dT_F- is the rate of flow of biological time corresponding to the process of photosynthesis, relative units·day^{-1}; dT_R- the rate of flow of biological time corresponding to the respiration process, relative units·day^{-1}. For calculations according to equation (12), we need to know the functional dependence of the processes of photosynthesis and respiration in ontogenesis in the form of a mathematical expression. But we can do without it since the processes of photosynthesis and respiration determine the increase in dry total biomass. Therefore, equation (12) is nothing more than a sigmoid plant growth curve expressed in relative units. That is, we believe that the movement of biological time is of the basics function of the processes of photosynthesis, respiration, and growth.

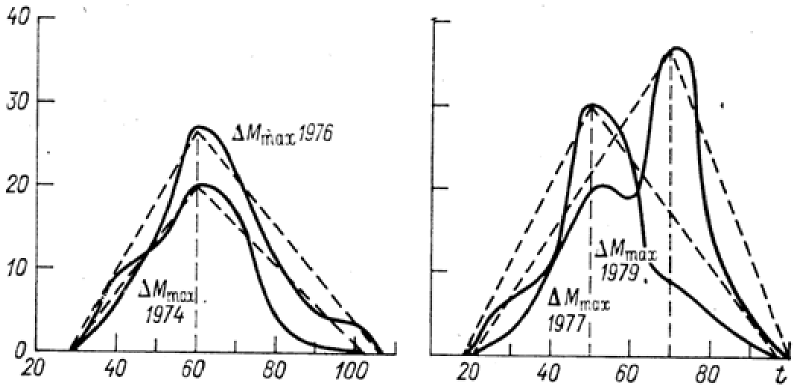
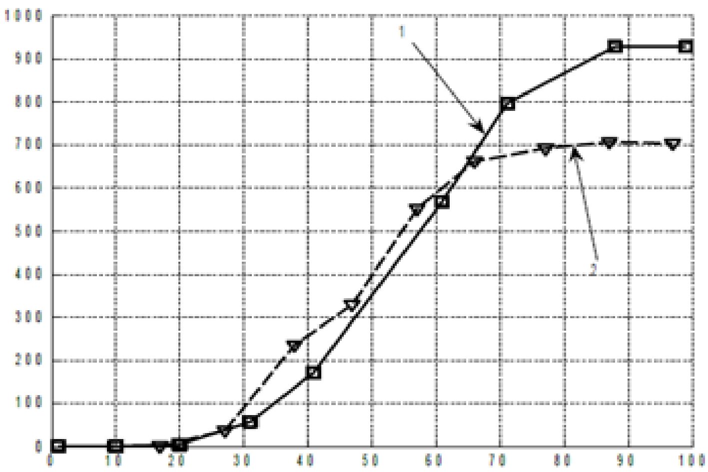


Figure 3: Increases in the total dry biomass of potatoes per square meter of soil surface during ontogenesis in different years, according to Tooming H.G. – 1984.

units of measurement — dM/dt, gdm·m^{-2}·days^{-1}



day from «shoots»

Figure 4: Sigmoid growth curve of total dry biomass of sunflower per square meter of soil surface: 1 — 1986 the yars; 2 -1987 the yars. biological time, day.

The biological time of a plant organism as a closed curvilinear integral

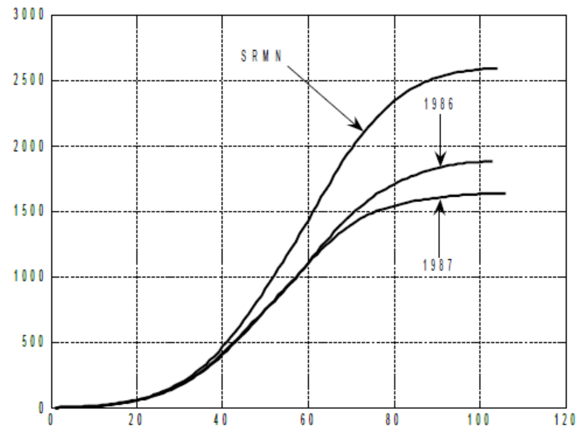
It is well known that crops such as sunflower, spring and winter wheat, barley and others begin their life cycle from a seed, and this life cycle continues until new seeds appear in the plant's organisms. That is, there is a movement of life from "seed" to "seed". In addition, the process of photosynthesis, its growth for the entire dry biomass during the day, starts from zero (we believe that there is no photosynthesis in the seed) and, passing its maximum during ontogenesis, again comes to zero (the growth processes at the time of maturation have stopped). More difficult with the respiration process. - We believe that the material process of respiration all the time occurs in the seeds of a plant as a basic component of life. Therefore, the process of respiration of the whole plant begins with a certain small value, passes a maximum during ontogenesis, and ends again with its small value. All this allows us to speak about the closedness of biological time inside the plant organism as a property that determines the basic component of plant life, and makes the plant follow from the beginning of life "seed" to the end of life again "seed". That is, inside the plant organism, the movement of biological time is carried out along a closed trajectory. This trajectory can be very diverse for different plant species. Closed trajectory can be either with self-intersections or without self-intersections. We'll look at one closed trajectory that goes to a sunflower plant. We will assume that in the simplest case, the closed trajectory of the movement of time inside the sunflower organism is a circle $r^2 = (X-1)^2 + Y^2$ (13) where r - is the radius of our time circle, relative units; X - the first-time coordinate, relative units; Y - the second time coordinate, relative units; the movement of time goes clockwise. Let us show that such a material movement of biological time in the ontogenesis of a sunflower along our time circle corresponds to its processes of growth and development. Let's write our time circle in parametric form $T_F(j) = 1 - \cos(2\pi t(j))$ (14) $T_R(j) = \sin(2\pi t(j))$ (15) here t(j) - parameter - physical time, varies from small t_0 to 1, rel. units; if t(j) is expressed in days , then it is equal to $1/t_E$, where t_E is the duration of the entire ontogenesis, rel.units·days-1 ; T_F(j) - the normalized value of the biological time corresponding to the process of photosynthesis, relative units; T_R(j) - the normalized value of the biological time corresponding to the respiration process, relative units; j - is the number of the day of the billing period. By the condition of the problem of calculating the biological time circle, we consider the temporary physical points t_0 and t_E the closed, that is, the same time point on the circle. Now we will find the length of our time circle, where this length corresponds to the duration of time of the entire ontogenesis, according to the equation $T(j) = \int_{t_0}^{t_E} \sqrt{T(j)^2_F + T(j)^2_R}\,dt$ (16) where T(j) - is the duration of the period of biological time from «shoots» to "maturation", relative units; t_0 - the initial value of the physical time corresponding to the "shoots" phase, relative units; t_{End} - the final value of physical time, corresponding to the "maturation" phase, relative units. We substitute into this equation (16) the parametric equations of the biological time of the processes of photosynthesis (13) respiration (14) and (15), and after transforming the equation, we get $T(j) = \int_{t_0}^{t_E} \sqrt{2 - 2\cos(2\pi t(j))}\,dt$ (17) Let us compare equation (14) with the integrand of equation (17). We see that the integrand (17) is very similar to equation (14). The integrand of equation (17) is the square root of the doubled equation (14). This suggests that the process of photosynthesis has a fundamental influence on the flow of biological time. The first coordinate of biological time is closely related to physical time. The first coordinate of the parametric equation of the time circle is in contact with physical time, corresponding to the process of photosynthesis. The second coordinate, its parametric equation (15) corresponds to the biological time of the breathing process and is orthogonal to the physical time. We see the process of respiration only by the gas exchange of O2 in the plant organism. That is, the total biological time of the processes of photosynthesis and respiration, in its movement inside the organism plant of a sunflower along the temporary circle, is subject to the process of photosynthesis. Using a dynamic model of the growth and development of sunflower, the production process [15] we can calculate the processes of photosynthesis and respiration of a sunflower plant throughout ontogeny. Thus, we can calculate the length (duration) of the biological time of the whole plant organism using equation (16). Only in equation (16), instead of the integral, the integral sum was taken for each lived physical day, (Figure 5). As seen in (Figure 5), we obtained images of the sigmoid curve growth depending on the agrometeorological conditions. Now we find the integral of equations (14) and (15): since this happens during the life of the plant $T^2{}_F(j) = \frac{-1}{2\pi}\sin(2\pi t(j)) + t + C_F$ (18) $T^2{}_R(j) = \frac{-1}{2\pi}\cos(2\pi t(j)) + C_R$ (19) where $T^2{}_F$(j) - is the square of the biological time corresponding to the process of photosynthesis for the entire ontogenesis, (relative units)2; $T^2{}_R$(j) - the square of the biological time, which corresponds to the respiration process for the entire ontogenesis, (rel. units)2; C_F , C_R - constants of integration, (relative units)2, (Figure 6). From (Figure 6), in the process of photosynthesis, its square of biological time always has positive values, which allows the growth of the organism to proceed in the material plane. That allows for the processes of new formation of biologically active substances. While the biological time of the respiration process has negative values in its ontogenesis, at the beginning and at the end of the growth and development of the organism, that is, it directs the material metabolic processes back (Figure 6). Based on mathematical and physical considerations, the integral (18) and (19) is nothing more than the work of the force field of the biological time of the plant during its growth. Such work is not material, since material processes do not participate in it, but only biological time. In addition, in (Figure 6) shows the point of contact of the two curves "budding" - this point may be the moment of ontogeny, when the budding process of the sunflower basket is observed, the process of its initiation in the upper meristem of the stems. At the same time, as can be seen without calculations, at the point along the axis of physical time t = 0.5, two cardinal points of values are observed: T_F - the inflection point of the curve is observed, and the maximum point T_R - which corresponds to the vegetative phase "flowering". It should also be noted that the obtained equations (18) and (19) are not provided with the influence of agrometeorological conditions in the ontogenesis of sunflower. These equations show the intrinsic properties of the plant organism in the processes of growth and development. Integration constants for the process of calculating biological time according to equations (18) and (19) are equal: C_F= 0 and C_R= 0.085, and they say that in the living organism of the seed there is always a time constant corresponding to the process of respiration. The biological time of the respiration process tends to be a constant contained in the genetic material of the seed, in the chromosomal material. We should also note one unique ability of a closed curvilinear integral of the second kind, which suggests that a closed curve can have a wide variety of properties and has the same solution. Let's show this for our biological time -circle, and another closed curve - an ellipse. Let's write a curvilinear integral of the 2-nd kind of the following form for our time ellipse

$$T^2{}_{obs}\left(j\right)=2\oint_V \alpha.T_F\left(j\right)dT_R-\beta.T_R\left(j\right)dT_F \quad (20)$$

where $T^2{}_{obs}(j)$ - is the work of the force field of the total biological time for the entire plant organism for the entire ontogenesis, (relative units of biological time)2; $T_F(j)$ - parametric equation of the time circle for the process of photosynthesis - (14); $T_R(j)$ - parametric equation of the time circle for the respiration process - (15); the differential of the respiration process dT_R = cos; the differential of the photosynthesis process dT_F = sin; v - is our time circle. Substituting here in equation (20), the parameters $\alpha+\beta=1$, we thereby obtain any time ellipse. Substituting here these parametric equations of the time circle and its differentials, we get a simple integral with integration parameters where the physical time t changes from 0 to 1, which can be calculated

$$T^2{}_{obs}\left(j\right)=\int_0^1\left[\alpha\left(1-\cos\left(2\pi t\right)\right)\cos\left(2\pi t\right)-\beta\sin^2\left(2\pi t\right)\right]dt \quad .(21)$$

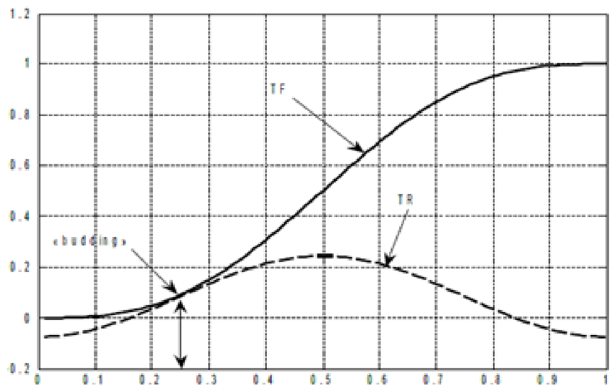
We have calculated such integrals for some ellipses. Their graph is shown in (Figure 7). Thus, choosing any values of $\alpha+\beta=1$, we can obtain any S-shaped time curve that describes the growth of the total dry biomass of the plant organism. Based on the integrand of equation (21), it can be divided into two integrals: for the biological time of the photosynthesis process and the biological time of the respiration process. In this case, one integral is obtained with a minus sign, which corresponds to the respiration process. It should be noted that the area of the circumscribing circle, as well as the area of the circumscribing ellipse, is always equal to 1, for these different values of $\alpha+\beta=1$. This means that the work of the force field of physical time in plant ontogenesis, during its life, in relative units, is always equal to 1. It remains for us to calculate the area of our time circle, it turns out our, any, temporary ellipse, according to the equation of the area of the circle and calculate the radius of this time circle $T^2{}_{obs}\left(E\right)=\pi r^2=1$ (22) where E - means that we take a temporary area at the end of ontogeny. Then, it follows from equation (22), the radius of our time circle in relative time units $r=\sqrt{\frac{1}{\pi}}=0,5642$ (23).



day of physical time from "shoots"

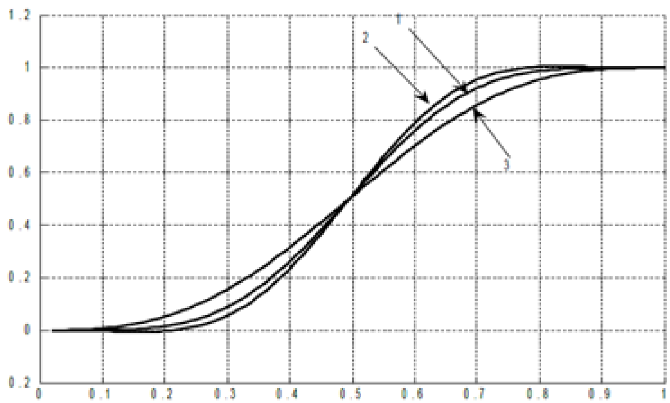
Figure 5: The general movement of the biological time of sunflower during ontogenesis, obtained from its model of the production process for three years of observations, according to equation (16): SRMN – average long-term agrometeorological conditions for 1975-1999; 1986 - agrometeorological conditions 1986, station "Chernomorka", city Odessa.

(Biological time)^2, (rel. units)^2



physical time, rel. units, $1/t_E$

Figure 6: Change of the integral of biological time corresponding to the process of photosynthesis - TF, and the integral of biological time corresponding to the process of respiration — TR, during ontogenesis of an annual plant. T2obs (j) - work of a temporary force field in ontogenesis, (rel. units)^2



physical time t, rel. units

Figure 7: Calculation of the curvilinear integral of the 2 - nd kind for time ellipses according to the equation (21): 1 – circle: $\alpha = 1/2; \beta = 1/2;$ 2 - ellipse: $\alpha = 3/4; \beta = 1/4;$ 3 - ellipse: $\alpha = 2/3; \beta = 1/3.$

Green's formula

Let us recall the equation that goes from a curvilinear closed contour to a double integral according to Green's formula $\int_c Pdx + Qdy = \int\int_G \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y} \right) dxdy$ (24) then we write Green's formula for our time circle and ellipses in the form $T^2_{obs}(j) = -2\oint_V -\beta T_R dT_F + \alpha T_F dT_R = -2\int\int_G (\alpha + \beta) dT_F dT_R$ (25) where G - our time circle, or the ellipse corresponding in area to this circle, as a temporary limited area, is a closed contour - v. Based on equations (20), (21) and equations (25), it can be seen that the area of the time circle always has the same value equal to 1 for any ellipses. In this case, equation (25) shows that, according to Green's formula, the movement of time does not go to zero, and this suggests that the movement of biological time depends on the path. According to Green's formula, the biological time of a plant has an area within itself, and a temporary surface in three-dimensional time space. And this fact entails the Ostrogradsky-Stokes formula and the associated temporary surfaces inside the plant organism and in the seed. More precisely, in growing cells and their chromosomal material. These temporary surfaces inside the plant organism, in my opinion, can be very diverse. This indicates the adaptability of the processes of growth, photosynthesis, and respiration of different plants, about their diversity. In conclusion, we can say that the process of photosynthesis and respiration of plants is inseparable from the biological temporary surface, which has the property of movement always when the plant's seed and organism are alive.

Discussion

We began our consideration of the biological time of a plant by accepting an important fact: the biological time of a plant differs from physical time and tends to stretch or contract depending on the current state of agrometeorological factors. Then, in a natural way, we obtained the scalar product of two-time vectors for one day of calculation in plant ontogenesis, according to the proven method of degree-days (effective air temperatures) (Guide to Agrometeorological Forecasts 1984) [16]. However, the method of degree-days (sums of effective temperatures) is in no way connected with the material processes of the plant organism. Then it became necessary to establish such a connection. The method of degree - days (sums of effective temperatures) gives an unambiguous representation of it as a sum of scalar products of two-time vectors for each day of calculations. One of them is closely related to physical time and our three-dimensional space, and the second time vector is deflected from it at a certain angle in the two-dimensional time space of the plant organism. Then, to calculate biological time, it is natural to use a curvilinear integral of the second kind. This was done with the assumption that the integrand of the curvilinear integral corresponds to the material processes of photosynthesis and respiration of the plant organism. First, we calculated the temporal length of the curve corresponding to the material processes of photosynthesis and respiration. But we could not get complete confirmation of the correctness of our statements based on an open curvilinear integral. In what follows, a closed curvilinear integral over a circle is considered. And already this circle gave full confirmation of the correctness of our research. We compared the parametric equations of our time circle with the normalized values of the processes of photosynthesis and respiration in plant ontogeny and obtained an unambiguous correspondence with the processes of changes in biological time. In addition, instead of the time circle, a time ellipse is considered. With its help, it is possible to select S-shaped curves of the growth of the organism of a plant of any kind. This correspondence is expressed by the sigmoid growth curve of an annual plant. In addition, it becomes clear that the parametric equations of the biological time of a plant can be repeated at each growing season of a plant's life, since they are expressed by trigonometric equations. In addition, the resulting integral of parametric temporal equations suggests that in the chromosomes of the seed, its cells, there is a constant value of the biological time process. Only this biological time, its process, is closed in chromosomes. This means that the seed has a living state, and when it gets into the right agrometeorological conditions (the right heat and moisture), the processes of growth and development, respiration and photosynthesis of the plant organism begin to be activated. The closed curvilinear integral of biological time is not equal to zero. This means that biological time depends on the path of its movement. And within this time domain there may be points or even some inner rip areas. Such an area of rupture can be a vacuole, where cell juice is present and there are no other components of the cell that perform cellular and organismal functions. According to Green's formula, we have a temporary surface inside a plant's body in its cells with a gap in the form of a vacuole. Living cells can be thought of as the additive sum of temporary surfaces in a plant organism. This easily follows from theorems on double and curvilinear integrals. At the same time, the time area on the plane can be represented as a temporary surface in a three-dimensional time space inside the plant organism, which can be projected onto a two-dimensional time plane. That is, such a statement unambiguously follows from Stokes' mathematical formula. Moreover, such a temporary surface in three-dimensional time space can be very diverse: from a ball to an ellipsoid and other surface, it can be open. But that's another study.

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