*are $N_{30}P_{50}K_{60}$ и $N_{60}P_{50}K_{60}$; seed fractions 1.7 и > mm, 2.0 и > mm, 2.2 и > mm (check variant) and 2.4 и > mm.*

*Sowing qualities of grown seeds are substantially independent of the size of sown seed material (fractional composition). Increasing the dose of nitrogen fertilization contributes to the yield and thousand-seed weight but adversely affects the laboratory germination and germination readiness. The highest seed yield of spring wheat is formed at fraction sowing 2.2 и > mm. This indicator amounted to 3.47-3.74 and 3.53-3.86 t/ ha, respectively, of Rannia 93 and Nedra varieties against applied $N_{30}P_{50}K_{60}$ и $N_{60}P_{50}K_{60}$ before sowing.*

***Key words:*** *spring wheat, seed fraction, fertilizers, variety, sowing qualities, yield.*

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# THEORETICAL BASES OF FORMING HIGHLY PRODUCTIVE CROPS OF BUCKWHEAT

**A. V. Rarok**
**Podilsky State Agrarian Technical University**
**V. Y. Bilonozhko, Doctor of Agricultural Sciences**
**Cherkassy National University named after Bohdan Khmelnytsky**
**S. P. Poltoretskyi, Doctor of Agricultural Sciences**
**Uman National University of Horticulture**

*Наведено аналітичний огляд вітчизняних і зарубіжних літературних джерел, щодо теоретичних основ формування високопродуктивних посівів гречки. Розробка теорії продукційного процесу зробила значний вплив на розвиток практичної селекція, моделювання, прогнозування й програмування врожаїв сільськогосподарських культур. Так, унаслідок перебудови габітусу рослин в процесі селекції у виробництво надійшли сорти гречки з підвищеною врожайністю і наявністю таких цінних ознак як крупноплідність, обмежене гілкування, детермінантність, ефективний розподіл асимілятів між вегетативними та генеративним органами. Використання таких сортів гарантує врожайність зерна гречки 20–25 ц/га і вище, що наближає її до рівня інших зернових культур.*

***Ключові слова:*** *теорія продукційного процесу, фотосинтез, синтетична селекція, урожайність, гречка.*

Increase in productivity of agricultural crops and protection from diseases and pests are the main issues of modern agrobiology. Thus, an important characteristic of an agrobiocenosis is the productional process. The basis of it is the ability of plants to absorb water and mineral substances from the soil, absorb carbon dioxide from the air and to synthesize organic substances through the energy of sunlight. The primary productivity of ecosystems or individual biocenoses is the rate at which energy of sunlight is absorbed by producers during photosynthesis accumulating in the form of organic matter. Analysis of the productional process by taking into account morphometric parameters is possible at different levels of organization of living matter – from cellular to ecosystem one. The level of species, population or ecosystem is crucial for the use of vegetation cover for the benefit of a man. Studying the productivity at the level of the organism and population can expand general biological understanding of the vital activity of systems at different levels and simultaneously solve practical problems.

At the end of the last century under the International Biological Program a significant amount of material was developed to study the productivity of terrestrial and aquatic ecosystems, as well as and the degree of impact of various factors on them. Climatic factors (temperature, light, the concentration of $CO_2$ in the air) as well as the presence of water and mineral nutrients, biocenosis structure and dynamics of its development influence on the formation of primary production. Ontogenesis of plants is divided into 10 stages and substages. Such gradation can be used to determine the state of both cultural and wild plants [1, 2].

In today’s technologies care for crops is aimed at not only providing the best living conditions for plants but also controlling the development of productivity components, forming the structure of the harvest in a given direction. This principle, that is the active care for the crops, was developed in the 70-ies of XX century and had a significant impact on increasing the productivity of agricultural crops in a number of European countries. The practical implementation of it is shown in constant monitoring of the state of crops, conducting of farming practices by phases of plant development and application of fertilizers (based on soil and plant diagnostics). At the same time, the quality of implementation of each agricultural arrangement is very important. Highly-productive sowing should be characterized by the density of productive plant stand, their high uniformity, optimal development of all plants and their resistance to lodging optimal for appropriate environmental conditions and variety. Particular attention is paid to the formation of optimum density of productive plant stand. It is well known that this element in the structure of the harvest has a decisive impact on crop productivity. Further, with the increase of farming, the share of influence of seeding rate tends to decrease. The uniformity of seed placement during sowing is important. Critical phases, during which the most efficient use of feeding, retardants, crop protection products, were determined.

There are several key indicators of the productional process. They are gross primary productivity, net primary productivity, net productivity of coenosis and secondary (net, gross) productivity. Gross primary productivity of plants (gross production) is the total energy, fixed by photosynthesis. The part of gross primary production is spent for respiration of plants, so the difference between gross production and such costs is the net primary productivity. It characterizes the rate of growth of biomass available for heterotrophs. Also, net productivity of coenosis is determined as the speed of accumulation of organic matter that is not consumed by heterotrophs. Secondary productivity is characterized by the rate of formation of organic matter at the level of heterotrophs (consuments). Secondary productivity is also divided into “net” and “gross” productivity [3].

Primary bio production is associated with several levels of the organization of living matter. The first stages of the photosynthetic process begin at the molecular level in quantosomes of chloroplast membranes where there is synthesis and accumulation of organic matter. The level of primary productivity is determined by the intensity and the ratio of photosynthesis and autotrophic respiration. The final stages of the productional process are related to features of cenoses as a biocommunity of organisms. There are many parameters that characterize the photosynthetic capabilities of plants but only a few are actually taken into account and controlled. They are divided into two groups: associated with the plant itself and viable condition; depend on environmental conditions.

The level of primary plant productivity depends on the functional activity of a leaf apparatus. Studies show that the content of chlorophyll per unit area of plant stand and per unit of leaf surface is not a factor of limiting photosynthesis. All plants are characterized by considerable excess of chlorophyll but under optimal lighting conditions increase in its concentration does not lead to increasing productivity. The nature of the surface and downiness of leaves, level of light reflection, angle of leaf attachment and duration of active photosynthesis are essential for effective use of chlorophyll in photosynthesis. In the process of evolution these parameters have been improved that, for example, dependence between chlorophyll and photosynthesis of plants of meadows is almost absent [4]. The development of leaf surface is important for characteristics of the productional process of plants. For its evaluation the leaf area index (LAI) which indicates the ratio of the size of leaf area of coenosis per unit area of sowing. There are optimal values of LAI for populations of different species in which the greatest degree of absorption of photosynthetically active radiation (PAR) is achieved. Depending on the shape of leaves, characteristics of their location and general architectonics of plant stand LAI that optimizes PAR absorption is 3.9 $m^2$ / $m^2$ and varies according to the phases of development. LAI for most grain crops is at the level of 4.0–5.0 $m^2$/ $m^2$ [3].

Deviations from the optimum value of LAI equally reduce biological productivity, albeit for different reasons. Thus, in liquefied coenoses the full use of solar radiation is not achieved and other environmental resources are not fully used. In over stocked coenoses, where shading of leaves located below increases, they are in the “zone of light starvation” and basically work on breathing. Further increase of LAI helps reduce the gross productivity. There are optimal values of LAI for populations of different species which is a variable and depend on changes of water regime, level of mineral nutrition, phase of development and more. The largest increase in biomass is observed at intermediate possible values of LAI At minimum and maximum values there is the smallest increase (due to shading and competition). High utilization rate of PAR during the growing season is ensured by the speed of forming plant leaf surface and its sustainable preservation throughout the period of photosynthetic activity.

Increasing crop productivity is the main task of plant biology and agriculture in response to the demand of growing world population of mankind for food and energy [5]. This task must be accomplished with minimizing the costs of agricultural production and environmental impact, taking into account the increasing $CO_2$ level and extreme conditions of moisture provision and temperature. In the recent past, agricultural production in general kept up with the needs of humanity as a result of the expansion of cultivated areas, selection of new varieties and intensification of cultivation technology. However, the increase in agricultural production is less efficient due to the growth of technology.

One of the fundamental components of plant productivity that has not fully been used in selection at improving the harvest is photosynthesis. There is increasing need to use knowledge of this fundamental process to address the need in providing people with food.

Thus, the selection is the most cost-effective, cheap and environmentally friendly arrangement of increasing agricultural production.

For centuries and now practical selection provided creation of more productive plant varieties based on the extensive type of the productional process. That means selection of varieties that can accommodate a growing number of photosynthetic units (chloroplasts, leaves) per unit volume and the seeding area under the maximum productivity of active photosynthesis. Also, factors of changing the structure, size and duration of the photosynthetic apparatus are involved. However, the photosynthetic apparatus and its activity are hardly changed and maintained at close level to its original one, or only the number of chloroplasts and other structural units changed ("Evans Paradox" is the effect of reducing the intensity of photosynthesis by the leaf area unit) [6]. As a result, there is a clear imbalance between genetically predetermined size of fruit organs and capabilities of their formation. Thus, increasing the area of leaves inevitably causes a situation when LAI reaches a critical size, as well as there is shading and decrease in the utilization rate of PAR. Then, the only way is selection of intensive type of the productional process to increase photosynthetic activity. However, analysis of the dynamics of increasing plant productivity shows that in recent years the yield of many crops reached a certain limit and even there is the tendency to reduce it [7]. After variety change, an adequate increase in productivity was not achieved. Although in many selection centers every year there is a significant number of varieties and hybrids of agricultural crops, there are not many of them that are better than varieties selected earlier. During extreme weather conditions productivity decreases rapidly. Further increase in crop productivity can be expected from the selection which is aimed at creating varieties with enhanced photosynthetic activity and intensive type of the productional process after exhausting the possibilities of extensive process. In other words, the moment of the development of selection is a transition to a new phase of *the synthetic selection*, based on the achievement of plant physiology, genetics, biochemistry and related life sciences, first of all, photosynthesis as the main source of biomass of the plant. Processes occurring in modern plant selection can be seen as a reflection of the words of K.A. Timiriazev "... Agriculture became what it is, thanks to the achievements of Agrochemistry and Plant Physiology" [8].

Progressive and efficient agriculture system should combine economic, scientific and technological means to improve the yield. Further effective approach to intensification and acceleration of modern crop selection for productivity is to increase the functional activity of photosynthetic apparatus [9].

The transition of world agriculture from extensive to intensive type of development under the current increase in energy and resource costs – that is the “green revolution” coincided with a comprehensive theory of photosynthetic productivity which substantiated scientific approaches to overcome the negative effects of intensification of farming [10]. Thus, prerequisites for the selection by physiological signs are established. Also, it is found that there is a wide range of variation of photosynthetic function, including forms with increased intensity of photosynthesis among wild plants of different ecological origin. A considerable diversity of photosynthetic activity is observed among 40 thousand samples of BIP wheat world collection named after M.I Vavilov.

Effective arrangement management of the productional process and creation of varieties and forms with intensive type of the productional process suitable for cultivation in different agro-climatic zones is the activation of the photosynthetic apparatus by means of selection on physiological and genetic basis. So, scientists [11] indicate that the selection based on physiological and biochemical processes of photosynthesis is necessary because only through the intensification of this basic metabolic process further increase in biological productivity is possible. K.A. Timiriazev began scientific development of photosynthesis research, as the foundation of agriculture. He argued that “... science is designed to make the work of a farmer more productive” [12]. There are three stages in the study of photosynthesis.

The first stage is in 1941 when L.A. Ivanov [13] established relationship between harvest, photosynthesis and respiration in “Photosynthesis and harvest”. He pointed out that the productivity is a function of the magnitude, duration and activity of the photosynthetic apparatus.

The second stage is in 1954 at the annual Timiriazev reading A. A. Nychyporovych [4] reported a comprehensive theory of photosynthetic productivity. Its essence is the justification of yield dependence on metabolic and agronomic activities related to the process of photosynthesis. This photosynthesis is a basic metabolic process that determines the level of productivity and causes increase of photosynthetic productivity. This justified management of productivity major factors such as the leaf area index of coenosis, its assimilative capacity, net photosynthesis productivity, economic efficiency factor and architectonics of coenosis as the optical system.

The third stage is when a large number of experimental data was piled up to the early 80s of the last century. As a result of it there was a need to link seamlessly the comprehensive theory of photosynthetic productivity with non photosynthetic processes and factors of harvest forming: growth and development, analysis of donor-acceptor regulatory systems of a plant, respiration processes and new aspects with connection with water regime and mineral nutrition. There was a theory of the productional process, subsequently generalized by the leading researcher of Plant Physiology, Academician A.T. Mokronosov [14].

The main provisions of this theory can be defined as follows: carbon, hydrogen and oxygen constitute 95% of the plant biomass. They are absorbed by a plant during photosynthesis with their storing in organic products, as well as transformed energy of solar radiation. Photosynthesis as a basic process in a plant metabolism provides energy substrate harvest formation, combined with the processes of assimilation of nitrogen and elements of mineral nutrition. It is controlled in a complex hierarchy of genetic programs of the development that determine the sequence of ontogenesis processes. V.A. Kumakov [6], A.T. Mokronosov [9] V.N. Liubimenko [15] and others have shown that photosynthetic function itself is controlled by ontogenesis processes. Also, they notice that yield formation is determined, above all, by the epigenetic pressure from organs consuming photosynthates. That is, among many factors the role of donor-acceptor relationship was determined between photosynthesizing and consuming organs in endogenous regulation of the whole plant with the support of bilateral functional relations of chloroplast, a cell and a leaf with the integrated system of the whole plant.

The value of development of the theory of the productional process for crop production progress has a real confirmation as it has a significant impact on the development of two areas: practical selection [16–18] and simulation, forecasting and programming yields [19].

**Conclusion.** Today, as a result of restructuring of plant habitus during selection there are buckwheat varieties with increased yield and presence of features such as large size of grain, limited branching, determinativeness and efficient allocation of photosynthates between vegetative and generative organs. Modern varieties have great practical value as factors of improving the efficiency of agricultural production. Their use ensures the grain yield of this crop not lower than 20–25 c/ha which brings it to the level of other cereal crops.

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## *Аннотация*

***Рарок А. В., Белоножко В. Я., Полторецкий С. П.***

### *Теоретические основы формирования высокопродуктивных посевов гречихи*

*Важной характеристикой агробиоценоза является продукционный процесс в основе которого находится способность растений поглощать из почвы воду и минеральные вещества, из воздуха усваивать углекислый газ и за счет использования энергии солнечных лучей синтезировать органические вещества. При этом, теория продукционного процесса позволяет расширить общебиологическое представление о жизнедеятельности систем различного уровня и одновременно решать практические задачи. Основные положения этой теории указывают, что 95% растительной биомассы составляют углерод, водород и кислород, которые усваиваются растением в процессе фотосинтеза с запасанием в органических продуктах как их самих, так и преобразованной энергии солнечной радиации. Фотосинтез, как основной процесс метаболизма в растении, обеспечивает энергосубстратное формирования урожая, сопряженное с процессами усвоения азота и элементов минерального питания, и находится под контролем сложной иерархии генетических программ развития, которые и определяют всю последовательность процессов онтогенеза. Фотосинтетическая функция контролируется процессами онтогенеза, а формирование урожая – детерминировано, прежде всего, эпигенетической нагрузкой со стороны потребляющих ассимилянты органов.*

*Разработка теории продукционного процесса оказала значительное влияние на развитие практической селекция, моделирование, прогнозирование и программирование* *урожаев сельскохозяйственных культур. Так, в результате перестройки габитуса растений в процессе селекции в производство поступили сорта гречки с повышенной урожайностью и наличием таких ценных признаков как крупноплодность, ограниченное ветвления, детерминантность, эффективное распределение ассимилянтов между вегетативными и генеративными органами. Использование таких сортов гарантирует урожайность зерна гречихи 20–25 ц/га и выше, что приближает ее к уровню других зерновых культур.*

***Ключевые слова:*** *теория продукционного процесса, фотосинтез, синтетическая селекция, урожайность, гречиха.*

### *Annotation*

***Rarok A. V., Bilonozhko V. Y., Poltoretskyi S. P.***

***Theoretical bases of forming highly productive crops of buckwheat***

*An important characteristic of an agrobiocenosis is the productional process. The basis of it is the ability of plants to absorb water and mineral substances from the soil, absorb carbon dioxide from the air and to synthesize organic substances through the energy of sunlight. At the same time, the theory of the productional process allows extending general biological understanding of vital functions of systems of different levels and simultaneously solving practical problems. The main provisions of this theory point out that carbon, hydrogen and oxygen constitute 95% of the plant biomass. They are absorbed by a plant during photosynthesis with their storing in organic products, as well as transformed energy of solar radiation. Photosynthesis as a basic process in a plant metabolism provides energy substrate harvest formation, combined with the processes of assimilation of nitrogen and elements of mineral nutrition. It is controlled in a complex hierarchy of genetic programs of the development that determine the sequence of ontogenesis processes. Photosynthetic function is controlled by ontogenesis processes and yield formation is determined, above all, by the epigenetic pressure from organs consuming photosynthates.*

*The development of the theory of the productional process has a significant impact on the development of two areas: practical selection and simulation, forecasting and programming yields. Thus, as a result of restructuring of plant habitus during selection there are buckwheat varieties with increased yield and presence of features such as large size of grain, limited branching, determinativeness and efficient allocation of photosynthates between vegetative and generative organs. The use of such varieties ensures the grain yield of this crop not lower than 20-25 kg/ ha which brings it to the level of other cereal crops.*

***Key words:*** *theory of the productional process, photosynthesis, synthetic selection, yield, buckwheat.*

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# ХАРАКТЕРИСТИКА ЗРАЗКІВ ПШЕНИЦІ М'ЯКОЇ ОЗИМОЇ ЗА ЗИМОСТІЙКІСТЮ

**Я. С. Рябовол, кандидат сільськогосподарських наук**
**Л. О. Рябовол, доктор сільськогосподарських наук**
**Уманський національний університет садівництва**

*У статті висвітлено проблему щодо морозо- та зимостійкості пшениці м'якої озимої, як одну із важливих питань селекційного процесу. Відмічено необхідність створення зимостійких вихідних форм культури. Виділено та охарактеризовано зразки, які можуть слугувати донорами генів цих ознак при створенні нових адаптивних сортів пшениці.*

***Ключові слова:*** *морозостійкість, зимостійкість, вихідний матеріал, донор генів, пшениця, селекція.*