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Kuts B. O.

REGULATION OF DONOR-ACCEPTOR RELATIONS IN THE SYSTEM OF DEPOSITION OF ASSIMILATES – GROWTH IN LEGUME PLANTS DURING GERMINATION

Vinnitsa Mikhailo Kotsiubynskyi State Pedagogical University, Ukraine

danotchka@gmail.com

The research of the last decades was important for understanding the regularities of functioning the donor-acceptor system, which is a chief mechanism for the assimilate redistribution between plant organs in ontogenesis. By the dynamics of the change in the arrival of donor-acceptor assimilates, we may establish the regularities of the system functioning and the peculiarities of their endogenous regulation at the early stages of plant development, when the capacity of the "request" for the plastic substances for the acceptor, the sensitivity to the effects is the highest. The intensity of the usage of deposited substances in cotyledons and their redistribution between vegetative and generative organs of plants, bean-rhizobial complexes, which are additional consumers of assimilates in legumes, can become an indicator of regulation in ontogenesis phases, biochemical balance in plants and culture productivity. In modern literature, the information about the bacterothera acting as a consumer of assimilates in the process of symbiotic nitrogen fixation is negligible. Although it is clear that the capacity of the process of fixing atmospheric nitrogen is possible only in the conditions of plastic substances and energy inflow to the bacteroids, which can provide the process of photosynthesis by itself. Under shortage conditions of photochemical reactions' products, there is an incomplete restoration of the productivity level of total CO_2 fixation and the rate of oxidized compounds assimilation in the cell, vacuoles and apoplast of leaves was observed and the pH of the apoplastic fluid increased the invertase activity, stimulating the cleavage of the sucrose in the apoplast of the leaf. In addition, applied growth stimulants increase the dry mass of plants and the net productivity of photosynthesis contribute to the accumulation of various forms of carbohydrates in the roots and fruits. In stems and leaves there was a tendency of sugar and starch content decrease. Drugs significantly reduce the content of all forms of nitrogen in the roots, stems and fruits, and increase the content of protein nitrogen in the leaves. The drug induces a strong development of the photosynthetic apparatus: laying more leaves, prolonging their active functioning, increasing the size of chlorenchymal cells and chloroplastogenesis improving. This is accompanied by increase of plastic compounds formation in leaves, followed by their outflow to the generative organs that leads to carpogenesis intensification, increassing of yield quantity and improved yield structure, oil content and quality in flax seed was also improved.

Light is one of the key factors in the environment which not only provides the process of autotrophic feeding, but also launches the program of photoromogenesis through the system of photoreceptors (phytochromes, cryptocrons, and phototropinum). This provides the de-etiolation, the formation of chloroplasts, leaf blades and, as a consequence provides the transition to autotrophic feeding. Seedlings in legumes, such as lupins, are endowed with a characteristic hypocotyle germinatting in the dark that demonstrates an exorbitantly high growth gradient with an elongated zone below the apex. Thus, germination in the dark – scotomorphogenesis is a regulator of inflow and outflow, accumulation of auxin in the hypocotyl growth zone. The practice leads to the production of high and sophisticated plants with a large number of leaves as a result of darkening, as well as low levels and quality of the crop. The usage of growth regulators can minimize the adverse effects of nitrogen feed abnormalities. The usage of retardants and growth promoters can be an effective means of improving the nutritional value and regulating the synthesis processes in subsequent stages of ontogenesis, taking into account the biochemical composition unique in its ratio.The obtained review of the theoretical material gives reasons for further experimental research and creating recommendations for introduction of the growth regulators usage of different orientations to optimize the productive process of legumes.

Keywords: heterotrophic phase, retardants, stimulants, beans, "source-sink"

Relation to the plans, themes, scientific research. The article is connected with the scientific

programs, plans and topics that are being developed at the department. The subject of the dissertation for obtaining the scientific degree of PhD biological sciences from the specialty 091 “Biology” according to the extract from the protocol No.4 of the meeting of the Academic Council of the VSPU named after M. Kotsiubynskyi of October 28, 2018: “Regulation of donor-acceptor relations in the depot system of assimilates – growth in legume plants in period of germination”.

Introduction. The research of the last decades was important for understanding the regularities of the donor-acceptor system functioning, which is an important mechanism for the assimilate redistribution between plant organs in ontogenesis.

According to Poprotska I. V. [10], the combined usage of light, gibberellin and retardants for artificial regulation of the tension of donor-acceptor relationships in a plant is an effective method for studying the role of phytohormones and finding out the features of using plant’s reserve compounds in experimental studies of germination processes. Implementation of donor-acceptor relations can occur in different systems: “photosynthesis-growth”, “deposition of assimilates-growth”, macro- and microsymbionts in the processes of symbiotic nitrogen fixation.

The main aim of research is focused on the functions of processing the “photosynthesis – growth” system, where the first one is the producer of assimilates, and the second process has the role of assimilates’ consumer.

Significantly less data exist in literature about the functioning of other systems in the plant. In particular, it is known that in the regulation of the donor-acceptor system a significant role can be played by the process of depositing photosynthesis products that can be used for the needs of fruits, root crops, and other economically valuable organs of plants during the period of improvement of photosynthesis due to changes in natural or experimental conditions. For experimentation, it is advisable to use stimulants and inhibitors of growth processes, which result in changes in the flow of assimilates to the acceptor and allows to establish the peculiarities of synthesis and deposition with retardants and phytohormones acting through influencing on these processes in the opposite way. For such regulation, it is expedient to apply exogenous treatment of plants, since only the sufficient source of assimilates deposited not only in the form of starch, proteins and fats but also in the form of structural polysaccharides that take place of a resource buffer and may be implemented by the source-sink system.

Changes in the polysaccharide complex of storage cells’ walls, the magnitude of using polysaccharides as back-up compounds, and especially the restructuring of cell walls due to the possible usage of hemicellulose and pectin fractions in the process of seed germination remain poorly understood.

By the dynamics of the change in the arrival of donor-acceptor assimilates, we may establish the regularities of the system functioning and the peculiarities of their endogenous regulation at the early stages of plant development, when the capacity of the “request” for the plastic substances for the acceptor, and the sensitivity to the effects is the highest.

The intensity of using deposited substances in cotyledons and their redistribution between vegetative and generative organs of plants, bean-rhizobial complexes, which are additional consumers of assimilates in legumes [3, 6], can become an indicator of regulation of ontogenesis phases, biochemical balance in plants and culture productivity.

In modern literature, the information about the bacterothera acting as a consumer of assimilates in the process of symbiotic nitrogen fixation is negligible, although it is clear that the capacity of the process of fixing atmospheric nitrogen is possible only in the conditions of plastic substances and energy inflow to the bacteroids, which can provide the process of photosynthesis by itself.

Stimulators of growth influence on the anatomical-morphological, physiological and biochemical characteristics of plants, change the nature of donor-acceptor relationships in plants that intensify the production and optimize the yield of crops. As for GA_3 result, the volume of cells of columnar parenchyma of eggplant type “Almaz” according to Rohach V. V. [12] did not change significantly and the size of the spongy cells is increased. In addition, applied growth stimulants increased the dry mass of plants and the net productivity of photosynthesis, contributed to the accumulation of various forms of carbohydrates in the roots and fruits. In stems and leaves there was a tendency of sugar and starch content decrease. Drugs significantly reduced the content of all forms of nitrogen in the roots, stems and fruits, increased the content of protein nitrogen in the leaves.

Instead of it, the classical retardant action mechanism of chlormequat chloride (CCC) during replenishment on oilseeds has the opposite effect on the DAR as under the influence of retardander the inhibition of linear growth of vegetative organs with the simultaneous restructuring the anatomical structure of the shoots and leaves (increasing of the stem diameter due to better development of measles, xylem, thickening of the bast fibers), the resistance of the flaxseed to planting increased. According to the authors opinion, the drug induces a strong development of the photosynthetic apparatus: laying more leaves, prolonging their active functioning, increasing the size of

chlorenchymal cells and chloroplastogenesis improving. This is accompanied by increase of plastic compounds formation in leaves, followed by their outflow to the generative organs that leads to carpogenesis intensification, increassing of yield quantity and improved yield structure, oil content and quality in flax seed was also improved [7, 11].

The analysis of the literature revealed that under shortage conditions of photochemical reactions' products, incomplete restoration of the productivity level of total CO_2 fixation and the rate of oxidized compounds assimilation in the cell, vacuoles and apoplast of leaves was observed and the pH of the apoplastic fluid increased the invertase activity, stimulating the cleavage of the sucrose in the apoplast of the leaf [1].

Light is one of the key factors in the environment which not only provides the process of autotrophic feeding, but also launches the program of photoromogenesis through the system of photoreceptors (phytochromes, cryptocrons, phototropinum). This provides the de-etiolation, the formation of chloroplasts, leaf blades and, as a consequence provides the transition to autotrophic feeding.

Light can change the implementation of the development program of plants that can be expressed in the speed and duration of growth changing in their individual parts.

Seedlings in legumes, such as lupins, are endowed with a characteristic hypocotyle that germinatting in the dark demonstrates an exorbitantly high growth gradient with an elongated zone below the apex. Thus, germination in the dark – scotomorphogenesis is a regulator of inflow and outflow, accumulation of auxin in the hypocotyl growth zone [8].

The practice leads to the production of high and sophisticated plants with a large number of leaves as a result of darkening, as well as low levels and quality of the crop. The usage of growth regulators can minimize the adverse effects of nitrogen feed abnormalities [9].

The growth of the phytohormones content in the organs of beans plants depends on the age of the plants and the illumination conditions. In the process of scotomorphogenesis there is a correlation between the change in biomass, the length of the hypocotyl and the content of the GA_3, whereas in the process of photoromogenesis the effect of zeatin is noted. Growing in the dark is a positive trend while the same in the light is opposite. Cellular distribution in the leaf was carried out with low cytokinin content in the light, whereas cell proliferation occurred at a higher level of these hormones. The largest content of GA was characteristic for leaves at the end of their growth. The increase of ABA level is noted in intensive length and biomass growth periods of leaves, roots in the light and hypocotyl in the darkness. Light increased the ratio of auxin and cytokinins in the roots of the beans and reduced it in the epicotyl [2]. In our opinion, one of the action mechanisms of the light can serve as artificial change in the content and phytohormones ratio, there is a small percentage of literature which discuss about the likely find differences between skotomorfohenesis still and processes for monocots and flowering plants, due to different level of phytohormones, biochemical composition and nature of spare parts.

Test for preparations for cereal seeds' pretreatment in laboratory and field conditions showed synergistic biological properties, manifested in the growth accelerating of cultivated plants; the infestation reducing of the root system of spring wheat and spring barley normal root rot and increase their productivity (in terms of complex usage with laminaria polysaccharide complexes) with a decrease in the rate of active substances' consumption [13].

In the case of using retardants is likely increased frost resistance. Thus, in the case of processing winter wheat varieties "Bunker" with tebukonazol was found out that even etiolated plants under conditions of changing the fatty acids ratio (reducing saturated palmitic fatty acid and unsaturated alpha-linolenic acid) were resistant at a temperature of -8°C [5].

Features of donor-acceptor system functioning in conditions of skoto- and photomorphogenesis jointly retardant actions confirm the determination results of the optimal paclobutrazol (PBZ) concentration to improve the growth of "Pontal" and "Supra" bean varieties. Plants, treated by PBZ of different concentrations during the pollination period demonstrated the laying of beans already on the 10^{th} day after pollination, increasing in the number of pods; adverse effects of deviation of nitrogen nutrition were minimized. However, PBZ concentrations higher than 8 mg/L were phytotoxic [9].

Terms of first visible signs appearance of the tuberous bacteria infection of the roots in different species of legumes are different. The appearance of it mostly often occurs during the development of the first true leaves in most legume crops. However, the formation of the first tubers of alfalfa seedlings is observed on the $4\text{-}5^{th}$ day after germination and on the $7–8^{th}$ day this process occurs in all legumes. The maximum term is 10 days of the heterotrophic phase. This may indicate that the treatment of growth regulators can contribute to more effective inoculation of bacteria and enhance nitrogen fixation, as well as formation of protein compounds and therefore more high-quality agricultural products. One of the theoretically possible consequences is switching on to autotrophic way of feeding and harvesting in the earliest and the shortest terms due to the unique qualitative and quantitative composition of legumes.

Conclusion. The use of retardants and growth promoters can be an effective means of improving the nutritional value and regulating the synthesis processes in subsequent stages of ontogenesis, taking into account the biochemical composition unique in its ratio.

The obtained review of the theoretical material gives reasons for further experimental research: the study of the mesostructure of organs under the action of drugs, the anatomical structure of seedlings and cotyledons during heterotrophic germination phase; the study of the intensity of photosynthetic processes, dark and light respiration, the content of proteins, carbohydrates, polysaccharide complex during germination, structural changes in hemicelluloses and pectins as well as the creating of recommendations for the introduction of the growth regulators usage of different orientations to optimize the productive process of legumes.

References

1. Chikov VI. The role of source-sink relations between photosynthetic and assimilate-consuming organs in regulation of plant photosynthesis. *Agri Res & Tech: Open Access J*. 2017; 5(2): 555659. doi:10.19080/artoaj.2017.04.555659
2. Golovatskaya IF, Karnachuk RA. Dinamika rosta rasteniy i soderzhanie endogennyih fitogormonov v protsesse skoto- i fotomorfogeneza fasoli. *Fiziologiya rasteniy*. 2007; 54(3): 461-8. [Russian] doi: 10.1134/s102144370703017x
3. Golunova LA. *Regulyatsiya produktsiynogo protsesu i simbiotichnoyi azotfiksatsiyi soyi za dopomogoyu retardantiv:* Abstr. PhDr. (Biol.). K., 2013. 20 s. [Ukrainian]
4. Kan L, Nie S, Hu J, Wang S, Cui SW, Li Y, et al. Nutrients, phytochemicals and antioxidant activities of 26 kidney bean cultivars. *Food and Chemical Toxicology*. 2017 Oct; 108(Pt B): 467-77. PMID: 27613272. doi: 10.1016/j.fct.2016.09.007
5. Korsukova AV, Gornostai TG, Grabelnych OI, Dorofeev NV, Pobezhimova TP, Sokolova NA, et al. Tebuconazole Regulates Fatty Acid Composition of Etiolated Winter Wheat Seedlings. *Journal of Stress Physiology & Biochemistry*. 2015; 11(4): 118-27.
6. Kuryata VG, Golunova LA. Vpliv hlormekvathloridu na formuvannya simbiotichnoyi sistemi soya – Bradyrhizobium japonicum. *Naukovi zapiski Ternopilskogo derzhavnogo pedagogichnogo universitetu. Seriya: biologiya*. 2011; 3(48): 79-83. [Ukrainian]
7. Kuryata VG, Khodanitska OO. Features of anatomical structure, formation and functioning of leaf apparatus and productivity of linseed under chlormequatchloride treatment. *Ukrainian Journal of Ecology*. 2018; 8(1): 918-26. doi: 10.15421/2018_294
8. Sánchez-Bravo J, Oliveros-Valenzuela MR, Nicolás C, Acosta M. Growing in darkness. *Plant Signal Behav*. 2008 Jun; 3(6): 406–8. PMID: 19704581. PMCID: PMC2634317. doi: 10.1007/s00425-007-0601-4
9. De Almeida OM, De Melo HC, De Aquino Portes T. Growth and yield of the common bean in response to combined application of nitrogen and paclobutrazol. *Rev Caatinga, Mossoró*. 2016; 29(1): 127-32. Doi: 10.1590/1983-21252016v29n115rc
10. Poprotska IV. Regulyatsiya donorno-aktseptornih vidnosin u roslin v sistemi «depo asimilyativ – rist» u protsesi prorostannya. VInnitsya: TOV «NilanLTD»; 2017. 122 p. [Ukrainian]
11. Rogach VV, Poprotska IV, Kuryata VG. Diya giberelinu i retardantiv na morfogenez, fotosintetichniy aparat ta produktivnist kartopli. *Visnik DnIpropetrovskogo unIversitetu. Biologiya, ekologiya*. 2016; 24(2): 416-20. [Ukrainian]
12. Rohach VV. Influence of growth stimulants on photosynthetic apparatus, morphogenesis and production process of eggplant (Solanum melongena). *Biosystems Diversity*. 2017; 25(4): 297-303. doi:10.15421/011745
13. Vlasenko NG, Teplyakova OI, Meteleva ES, Polyakov NE, Halikov SS, Dushkin AV. Effektivnyiy preparat dlya predposevnoy obrabotki semyan zernovyih kultur na osnove kompleksov tebukonazola s polisaharidami laminarii. *Uspehi sovremennogo estestvoznaniya*. 2017; 12: 28-37. [Russian] doi 10.17513/use.36601

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РЕГУЛЯЦІЯ ДОНОРНО-АКЦЕПТОРНИХ ВІДНОСИН В СИСТЕМІ «ДЕПО АСИМІЛЯТІВ – РІСТ» У БОБОВИХ РОСЛИН В ПЕРІОД ПРОРОСТАННЯ

Куц Б. О.

Резюме. Дослідження останніх десятиліть стали важливими для усвідомлення закономірностей функціонування донорно-акцепторної системи, що є важливим регулюючим механізмом перерозподілу асимілятів між органами рослини в онтогенезі. За динамікою зміни надходження донорно-акцепторних асимілятів, можна встановити закономірності функціонування системи та особливості їх ендогенної регуляції на ранніх етапах розвитку рослин, коли потужність «запиту» на пластичні речовини для акцептора, чутливість до впливів є найвищими.

У сучасній літературі інформація про бактеріотере, що виступає в ролі споживача ассимилятов в процесі симбіотичної фіксації азоту, незначна. Хоча очевидно, що пропускна здатність процесу фіксації

атмосферного азоту можлива тільки в умовах пластичної речовини і припливу енергії до бактеріоіди, що може забезпечити сам процес фотосинтезу. В умовах дефіциту продуктів фотохімічних реакцій спостерігається неповне відновлення рівня продуктивності загальної фіксації CO_2 і швидкості асиміляції окиснених сполук у клітині, вакуолях і апопласті листя. Крім того, стимулятори росту що застосовуються збільшують суху масу рослин, а чиста продуктивність фотосинтезу сприяє накопиченню різних форм вуглеводів в коренях і плодах. У стеблах і листках спостерігається тенденція до зниження вмісту цукру і крохмалю. Препарати значно знижують вміст всіх форм азоту в коренях, стеблах і плодах, а також підвищують вміст білка азоту в листі.

Використання ретардантів та стимуляторів росту може стати ефективним засобом підвищення харчової цінності та врегулювання процесів синтезу на подальших етапах онтогенезу з огляду на унікальний за своїм співвідношенням біохімічний склад. Інтенсивність використання депонованих в сім'ядолях резервних сполук та їх перерозподіл між органами рослин, бобово-ризобіальними комплексами можуть стати індикатором регуляції фаз онтогенезу, біохімічного балансу в рослині та продуктивності культури. Отриманий огляд теоретичного матеріалу дає підстави для подальших експериментальних досліджень, а також розробки рекомендацій щодо впровадження використання регуляторів росту різної спрямованості для оптимізації продуктивного процесу бобових культур.

Ключові слова: гетеротрофна фаза, ретарданти, стимулятори, боби, «source-sink».

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РЕГУЛЯЦИЯ ДОНОРНО-АКЦЕПТОРНЫХ ОТНОШЕНИЙ В СИСТЕМЕ «ДЕПО АССИМИЛЯТОВ – РОСТ» У БОБОВЫХ РАСТЕНИЙ В ПЕРИОД ПРОРАСТАНИЯ

Куц Б. А.

Резюме. Исследования последних десятилетий стали важными для понимания закономерностей функционирования донорно-акцепторной системы, которая является важным регулирующим механизмом перераспределения ассимилятов между органами растения в онтогенезе. По динамике изменения поступления донорно-акцепторных ассимилятов, можно установить закономерности функционирования системы и особенности ее эндогенной регуляции на ранних этапах развития растений, когда мощность «запроса» на пластические вещества для акцептора, чувствительность к воздействиям являются самыми высокими. Интенсивность использования депонированных в семядолях резервных соединений и их перераспределение между органами растений, бобово-ризобиальными комплексами могут стать индикатором регуляции фаз онтогенеза, биохимического баланса в растении и производительности культуры.

В современной литературе информация о бактериотере, выступающей в роли потребителя ассимилятов в процессе симбиотической фиксации азота, незначительна. Хотя очевидно, что пропускная способность процесса фиксации атмосферного азота возможна только в условиях пластического вещества и притока энергии к бактериоидам, что может обеспечить сам процесс фотосинтеза. В условиях дефицита продуктов фотохимических реакций наблюдается неполное восстановление уровня продуктивности общей фиксации CO_2 и скорости ассимиляции окисленных соединений в клетке, вакуолях и апопласте листьев. Кроме того, применяемые стимуляторы роста увеличивают сухую массу растений, а чистая продуктивность фотосинтеза способствует накоплению различных форм углеводов в корнях и плодах. В стеблях и листьях наблюдается тенденция к снижению содержания сахара и крахмала. Препараты значительно снижают содержание всех форм азота в корнях, стеблях и плодах, а также повышают содержание белка азота в листьях.

Использование ретардантов и стимуляторов роста может стать эффективным средством повышения пищевой ценности и регулирования процессов синтеза на последующих этапах онтогенеза с учетом уникального по своему соотношению биохимического состава. Полученный обзор теоретического материала дает основания для дальнейших экспериментальных исследований, а также разработки рекомендаций по внедрению использования регуляторов роста различной направленности для оптимизации продуктивного процесса бобовых культур.

Ключевые слова: гетеротрофная фаза, ретарданты, стимуляторы, бобы, «source-sink».

The authors of this study confirm that the research and publication of the results were not associated with any conflicts regarding commercial or financial relations, relations with organizations and/or individuals who may have been related to the study, and interrelations of coauthors of the article.

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