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SQUARE OF LEAF SURFACE OF PEA DEPENDING ON TECHNOLOGICAL TECHNIQUES IN THE CONDITIONS OF THE WESTERN FOREST STEPPE

Annotation

Active leaf activity,stipules and whiskers of allows the development of production processes in plants and significantly affects the intensity of photosynthesis during the growing season. Optimal growth and development of plants, that affects the accumulation of organic matter and level of supply of mineral nutrients also depents of leaf surface square.

The results of researches where was learned the square of leaf surface and its influence to yield of modern varieties of pea depending on different doses of mineral fertilizers and growth regulators in the conditions of the western forest steppe are presented in the article .

Experimental part was conducted during 2016-2018 on the research field of the Training and Production Center "Podillya" PDU. The soil of the research field – is chernozem chernic, deep глибокий low humus, heavy loam on woody loams.

It's set out, that square of leaf surface of pea varieties Gotovsky, Chekbek and Fargus depented on \ varietal features of culture and technological measures which were applied in the reserch. Spraying of crops of PlantaPeg, Emistim C and Vimpel growth regulators in microstages BBCH 55-65 has provided active formation of the leaf surface area of pea plants.

During the growing season the square of assimilation surface has grown and reached досягла maximum values in microstages BBCH 60-65. The actions of the PlantaPeg regulator in plants of the Gotovsky variety the aquare og leaf surface fluctuateв from 176,4 til 330,2 square centimeters per plant, Chekbek – from 218,3 till 394,5 square centimeters per plant and Fargus – from 167,2 till 317,0 square centimeters per plant. In plants sprayed with Emistim C, the leaf surface area increased from 190.6 to 407.5 cm2 / plant, depending on the varieties, but the growth regulator Vimpel worked best on all studied varieties of peas - sowing ranged from 218.0 to 415.1 cm2 / plant.

Keywords. *pea, mineral fertilizers, regulators of growth, leaf surface area, yield capacity.*

Introduction. The main photosynthetic organ of plants are the leaves, and the photosynthesis that takes place in them is a unique process of converting the energy of light into the energy of chemical bonds, which are necessary for general plant metabolism and involves sequential photosynthetic reactions, which are carried out in the plant due to the energy of the photosynthetically active spectrum of solar radiation. Photosynthesis of crops is uneven in different periods of vegetation of culture. The total accumulation of vegetative mass depends on, both from the leaf surface, which is formed in the interphase periods of growth and development of plants in crops, and the duration of this period [1, 2].

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The leaf area square of crops and photosynthetic potential are closely related. The active activity of leaves, stipules and whiskers of pea allows the production processes in the plant during the growing season. Natural factors such as light, temperature, soil moisture, the level of supply of mineral nutrients have a significant impact on the accumulation of organic matter and the intensity of photosynthesis [3].

Analysis of recent research and publications. According to the results of research by L. Yeremko, V. Gangur, O. Kyrychko, D. Sokyrko [7] it is established that one of the way of increasing of general productivity of plants is to enhance their photosynthetic activity. Therefore, it is necessary to increase the utilization rate of solar radiation. This can be achieved by increasing the size of the leaf surface of plants, extending the duration of active leaf activity, adjusting the density of standing plants.

A. Nichiporovich, E. Koshkin [8, 9] tells that in the initial period of plant growth the leaf area increases to the flowering phase, and then begins to decrease in later phases due to the formation of productive organs. To improve the performance of the photosynthetic apparatus, it is important to consider the factor of mineral fertilizers and plant growth regulators. The study of the influence of plant growth regulators on the formation of the optimal leaf surface area and photosynthetic potential of pea crops in the Western Forest-Steppe is a topical issue today [10].

The goal of the reserch was to identify the dependence of the formation of the leaf surface area of pea plants on the level of fertilizer with different doses of mineral fertilizers and growth regulators in the Western Forest-Steppe.

Methodology of the research. Field research was conducted during 2016-2018 in the research field of the Training and Production Center "Podillya" of the Higher Education Institution "Podilsk State University", which were laid in the research ten-crop rotation.

The soil of the experimental field is typical chernozem, deep low-humus heavy loam on forest-like loams. According to the research of the Department of Agriculture, Soil Science and Plant Protection it is established that the research area is characterized by the following agrophysical and agrochemical properties of the soil: the density of the solid phase of the soil layer 0-30 cm is 2.55-2.62 g / m3; pH of aqueous and saline suspensions and hydrolytic acidity by the Kappen method in the modification of CINAO (GOST 26212-91). Thus, the pH of water in the upper layer is: 6.8 a, hydrolytic acidity is 0.70 mg-eq./100 g of soil. The humus content of the Turin humus content in the CINAO modification (GOST 26213-84) in the upper horizon is 3.39%. Density of folding - 1,17-1,25 g / m3; total porosity - 51.6-54.7%, nitrogen content (according to Cornfield) - 13.6-14.2, phosphorus and potassium according to Chirikov (DSTU-4115-2002) - 15.7-16.4 and 22, 4-26.3 mg per 100 g of soil, respectively. Absorption capacity at the level of 20-25 mg-eq./100 g of soil.

The sown area of the elementary plot was 50 m2, the accounting area was 48 m2. Predecessor - winter wheat. Tillage was carried out generally for the Forest-Steppe zone of Ukraine.

Seeds were sown with a grain seeder, the usual row method with a row spacing of 15 cm, with a seed wrapping depth of 5-6 cm and a sowing rate of 1.2 million / ha of similar seeds for all varieties of peas we studied. After sowing on the 2nd day, the sown area was rolled with a ring roller. The research was carried out according to the scheme in a three-factor field experiment by the method of randomized split sites. Repetition of variants four times [11].

Table 1. Scheme of field experiment

Factor A: variety	Factor B: enrichment	Factor C: growth regulators
A_1 - Gotovsky,	B_1 - $P_{30}K_{45}$ (control)	C_1 – without regulators of growth (control)
A_2 - Fargus	B_2 - $N_{15}P_{30}K_{45}$	C_2 – Emistim C, 30 ml / he
A_3 - Chekbek	B_3 - $N_{30}P_{30}K_{45}$	C_3 – PlantaPeh, 25 g/he
	B_4 – $N_{45}P_{30}K_{45}$	C_4 – Vympel, 30 ml/he

Research results. Effects on the photosynthesis of nitrogen, phosphorus and potassium are of great interest to many scientists. The action of nitrogen enhances the synthesis of the compound of protein and chlorophyll, provides a more complete use of assimilants and promotes their better formation. In particular, potassium increases the intensity of photosynthesis. Phosphorus promotes faster development of the root system of the plant. But the intensity of photosynthesis may decrease not only due to lack of mineral elements, but also due to an excess of one of them [12].

It was found that in the control version ($P_{30}K_{45}$) and without using of plant growth regulators, the dynamics of leaf surface area in the studied pea varieties was the lowest during 2016 - 2018.

Examining the area of the assimilation surface in the microstage BBSN 12-13, we found its growth with increasing doses of nitrogen. If in the variant of fertilizer $P_{30}K_{45}$ (control) the leaf surface area in the pea variety Gotovsky was 11.6 cm^2 / plant, Chekbek - 14.7 cm^2 / plant and Fargus - 10.3 cm^2 / plant, then in the areas where mineral fertilizers were applied fertilizers in doses $N_{15}P_{30}K_{45}$, the assimilation surface area increased to 13.3; 16.3 and 11.5 cm^2 / plant, respectively.

After application of N_{30} and N_{45} nitrogen, the leaf surface index increased by an average of 1.2 - 1.9 cm^2 / plant, depending on the variety (Table 2).

Table 2. Dynamics of the leaf surface area of pea plants depending on the influence of mineral fertilizers and plant growth regulators, cm^2 / plant (average for 2016 - 2018)

Factor B	Factor C	Factor A								
		Gotovsky			Chekbek			Fargus		
		Development phase (on a scale) BBCH								
		51-59	60-69	70-79	51-59	60-69	70-79	51-59	60-69	70-79
I	I*	101,7	145,3	71,8	113,5	179,7	97,4	93,5	136,5	64,8
	II*	102,2	176,4	85,0	114,4	218,3	117,1	94,3	167,2	77,9
	III*	103,3	200,1	90,1	116,2	247,6	129,8	95,4	190,6	83,3
	IV*	105,1	218,0	96,7	118,5	269,7	140,7	96,7	208,1	89,9
II	I*	119,5	173,3	84,5	133,7	209,5	110,7	109,9	163,0	76,3
	II*	124,7	219,2	102,7	140,5	263,3	137,8	114,7	208,1	97,1
	III*	128,2	226,9	110,5	143,8	272,4	142,9	117,9	215,4	101,2
	IV*	134,6	243,7	119,0	150,9	292,5	153,4	123,8	231,7	109,1
III	I*	133,5	214,9	108,5	149,4	255,7	136,7	122,9	203,4	96,4
	II*	138,8	273,1	135,4	156,1	329,1	172,1	127,8	260,6	124,8
	III*	144,9	281,4	141,3	162,8	337,2	178,2	133,3	268,5	130,0
	IV*	152,2	290,3	147,2	170,8	353,8	184,7	140,1	276,8	135,2
IV	I*	135,9	270,0	134,2	153,1	323,8	170,5	125,3	258,0	124,0
	II*	144,2	330,2	163,9	162,4	394,5	205,9	132,9	317,0	150,7
	III*	152,2	340,9	167,0	171,5	407,5	211,7	140,2	327,1	153,4
	IV*	154,7	347,2	173,9	174,1	415,1	217,4	142,5	333,2	159,7

Примітка: I - $P_{30}K_{45}$ (control), II - $N_{15}P_{30}K_{45}$, III - $N_{30}P_{30}K_{45}$, IV - $N_{45}P_{30}K_{45}$
I* - without processing (control), II* - PlantaPeh, III* - Emistym C, IV* - Vympel

In the optimal weather conditions of 2016-2017, the leaf surface area of pea plants was the best. But on average over three years on the fertilizer variants $N_{15}P_{30}K_{45}$ in combination with the plant growth regulator PlantaPeg in the varieties Gotovsky (control), Chekbek and Fargus the assimilation floor area was 124.7 cm^2 / plant, 140.5 cm^2 / plant and 114.7 cm^2 /plant. After the application of the growth regulator Emistim C and the same dose of mineral fertilizers, these indicators increased insignificantly by only 8-10.1 cm^2 / plant, and after the application of the growth regulator Vimpel - by 13.9-17.2 cm^2 / plantWith increasing doses of mineral nitrogen to N_{30} and N_{45}, the area of assimilation surface of plants of our studied pea varieties increased by an average of 31.3 - 33.7%.

Analyzing the dynamics of the formation of leaves, stipules and whiskers, we can note the maximum area of the assimilation surface in the phase of full flowering, ie in microstages BBCH 60-69 on all fertilizer options. Thus, in the variant without nitrogen ($P_{30}K_{45}$) in this microstage (full flowering) the leaf surface index was 145.3, 179.7 and 136.5 cm^2 / plant for Gotovsky, Chekbek and Fargus varieties, respectively. After spraying with PlantaPeg, Emistim C and Vimpel growth regulators for three years, the assimilation surface area increased to 176.4-254.7; 218.3-257.6 and 136.5 -194.6 cm^2 / plant, respectively.

On the feeding variant $N_{15}P_{30}K_{45}$ and without ristregulators (control) the leaf surface area increased by 26.5-29.7 cm^2 / plant, and after the application of these drugs by another 68.7-83.0 cm^2 / plant, depending on the varietal characteristics of peas . A similar tendency to increase the leaf surface area in pea plants of Gotovsky, Chekbek and Fargus varieties was obtained after the application of mineral fertilizers in the dose of $N_{30}P_{30}K_{45}$ in combination with plant regulators PlantaPeg, Emistim C and Vimpel. In the same variant of fertilizer, the highest value of the leaf surface area was recorded in the variety Chekbek 329.1-353.8 cm^2 / plant, which is 28.7-38.4% more compared to the control variant. In the Gotovsky variety, the assimilation surface area ranged from 273.1-317.5 cm^2 / plant, depending on growth regulators, which is 27.1-35.1% more than the control. Under the action of the same fertilizer composition for the variety Fargus, the leaf surface area was in the range of 260.6-276.8 cm^2, which is 28.1 - 36.1% more than the control.

It was investigated that the application of mineral fertilizers in doses of $N_{45}P_{30}K_{45}$ and after spraying crops with the growth regulator Vimpel in peas of the Checkbeck variety, the leaf surface area became the maximum - 415.1 cm^2 / plant. They were slightly smaller in the varieties Gotovsky - 347.2 cm^2 / plant and Fargus - 333.2 cm^2 / plant. After application of the same dose of mineral fertilizers and spraying of crops with PlantaPeg and Emistim C regulators in Chekbek variety the assimilation surface area was 394.5 cm^2 / plant and 407.5 cm^2 / plant, in Gotovsky variety - 330.2 and 340.9 cm^2 / plant and in the variety Fargus - 317.0 and 327.1 cm^2 / plant.

It was found that the area of pea leaves in the microstages BBCH 70-79 significantly decreased, due to the biological characteristics of the culture. Increased outflow of plastic substances from the vegetative organs into the seeds caused the death of the lower tiers of leaves during the ripening of pea crops. The assimilation surface area in these microstages decreased by an average of 49.7-51.2% for the cultivar Gotovsky, by 52.6-54.2% for the cultivar Chekbek and by 46.8-48.0% for the cultivar Fargus, depending on from the introduction of different doses of mineral nitrogen. On the variants where the growth regulator Vimpel was used in combination with mineral fertilizers at the dose of $N_{45}P_{30}K_{45}$, the leaf surface area was the largest and amounted to 173.9 cm^2 / plant in the variety Gotovsky, 217.4 cm^2 / plant in the variety Checkback and 159.7 cm^2 / plant in the variety Fargus. We investigated a slight decrease in leaf surface area only after spraying plants with PlantaPeg and Emistim C on average by 2.7 - 11.5 cm^2 / plant, depending on the variety.

The biological yield of crops, including peas, depends on many factors. Field germination of crops, preservation of plant density before harvest, symbiotic potential, assimilation surface size, intensity of photosynthesis in leaves and stipules, accumulation of dry matter, ultimately affect their productivity [13, 14, 15].

Over the years of research we have a serious task to study and compare the biological yield of modern varieties of peas with different doses of mineral fertilizers and growth regulators in the Western Forest-Steppe (Table 2).

On average for 2016-2018, the yield of pea grain in the control variants ($P_{30}K_{45}$) and without treatment of plants with growth regulators was 2.11 t / ha in the pea variety Gotovsky, in the varieties Chekbek and Fargus 2.68 t / he and 1.82 t / he, respectively

Table 2. Pea grain yield depending on fertilization with mineral fertilizers and growth regulators, t / he (average for 2016-2018)

Factor B	Factor C	Factor A		
		Gotovkiy	Chekbek	Farbus
$P_{30}K_{45}$ (control)	Without processing (control)	2,11	2,68	1,82
	PlantaPeh	2,55	3,05	2,42
	Emistym C	2,74	3,18	2,51
	Vympel	2,85	3,31	2,64
$N_{15}P_{30}K_{45}$	Without processing (control)	2,67	3,23	2,50
	PlantaPeh	3,17	3,75	2,95
	Emistym C	3,34	3,87	3,06
	Vympel	3,53	3,97	3,15
$N_{30}P_{30}K_{45}$	Without processing (control)	3,08	3,47	2,84
	PlantaPeh	3,60	4,00	3,13
	Emistym C	3,71	4,15	3,22
	Vympel	3,79	4,32	3,30
$N_{45}P_{30}K_{45}$	Without processing (control)	2,98	3,00	2,48
	PlantaPeh	3,28	3,34	3,01
	Emistym C	3,42	3,60	3,13
	Vympel	3,52	3,70	3,21
	HIP_{05} factor A	*0,035*		
	HIP_{05} factor B	*0,040*		
	HIP_{05} factor C	*0,040*		

In the areas where the PlantaPeg growth regulator was used, the yield increased to 2.55-3.05 t / he, under the action of the Emistim C regulator to 2.74-3.05 t / he and under the action of the Vimpel regulator to 2.85-3.31 t / he depending on the variety. Increasing the doses of mineral fertilizer to N15P30K45 provided an increase in yield by an average of 0.56-0.63 t / he on options without spraying with growth regulators. In the crops of the varieties studied by us where these drugs were used, these indicators increased by 0.65-0.86 t / he.

The maximum grain yield of Pea variety Chekbek - 4.32 t / ha, observed in areas where mineral fertilizers were applied in doses $N_{30}P_{30}K_{45}$ in combination with the growth regulator Vimpel, for varieties Gotovsky and Fargus, these figures were 3.79 t / ha and 3, respectively. 3 t / ha. Yields were slightly lower due to the actions of Emistim C and PlantPeg regulators. Thus, for peas of the Chekbek variety the yield was at the level of 4.0-4.15 t / ha, for the Gotovsky variety 3.60-3.71 t / ha and for peas of the Fargus variety 3.13-3.22 t / ha.

Conclusions. The study of the impact of different doses of mineral fertilizers in combination with growth regulators in a single technological process during 2016-2018 showed that the effect of each of the factors depended on the effectiveness of their interaction. Therefore, in the variants where nitrogen fertilizers were applied, the leaf surface area was larger, as the action of nitrogen increased the synthesis of protein and chlorophyll and provided more complete use of assimilants, which had a positive effect on pea grain yields Gotovsky, Chekbek and Fargus.

References

1. Pilipenko V.S., Kalenskaya, S.M. (2017). Leaf surface area and photosynthetic potential of pea plants depending on fertilizer and seed inoculation. *Bulletin of Agricultural Science, № 4,* 17–22. Access mode: http://nbuv.gov.ua/UJRN/vaan_2017_4_5.Razaq, M., Zhang, P., Shen, H., & Salahuddin. (2017). Influence of nitrogen and phosphorous on the growth and root morphology of Acer mono. PLOS ONE, 12 (2), e0171321. DOI: https://doi.org/10.1371/journal.pone.0171321

2. Di Paolo, E., Garofalo, P., & Rinaldi, M. (2015). Irrigation and nitrogen fertilization

treatments on productive and qualitative traits of broad bean (Vicia fabavar.minorL.) in a Mediterranean environment. *Legume Research*, *38 (2)*, 209. DOI: https://doi.org/10.5958/0976-0571.2015.00069.7

3. Nebaba, K.S. (2020). Formation of photosynthetic apparatus of sowing peas depending on technological methods in the conditions of the Western Forest-Steppe. *Sustainable Nature Management, 3*, 139–145. DOI: https://doi.org/10.33730/2310-4678.3.2020.

4. Kumar, K., & Goh, K. M. (2000). Biological nitrogen fixation, accumulation of soil nitrogen and nitrogen balance for white clover (Trifolium repens L.) and field pea (Pisum sativum L.) grown for seed. *Field Crops Research*, *68, Is. 1*, 49-59.

5. Yeremko L.S., Gangur, V.V., Kyrychok O.O., Sokyrko D.P. (2019). Mineral nutrition as a factor in increasing photosynthetic productivity and yield of pea crops. *Bulletin of the PDAA, 3,* 50−56. DOI: https://doi.org/10.31210/visnyk2019.03.06

6. Koshkin, E.I. (2005). Private physiology of field crops. Textbook. allowance. Moscow: Kolos.

7. Nichiporovich, A.A. (1972). Photosynthetic activity of plants and ways to increase their productivity. Theoretical foundations of photosynthetic productivity. Moscow: Nauka.

8. Gangur, V.V., Yeremko, L.S., & Saenko, V.O. (2021). Dynamics of leaf surface formation of sowing rate and productivity of its photosynthetic activity depending on the level of mineral nutrition. *Agrarian innovations. № 8.* 2021. DOI: https://doi.org/10.32848/agrar.innov.2021.8.3

9. Dospekhov, B.A. (1985). *Methods of field experience*. Moscow: Agropromizdat.

10. Nichiporovich, A.A. (1972). *Photosynthetic activity of plants and ways to increase their productivity. Theoretical foundations of photosynthetic productivity*. Moscow: Nauka.

11. Mazur, V., Didur, I., Myalkovsky, R., Pantsyreva, H., Telekalo, N., & Tkach, O. (2020). The Productivity of intensive pea varieties depending on the seeds treatment and foliar fertilizing under conditions of right-bank forest-steppe Ukraine. *Ukrainian Journal of Ecology*, *10(1)*, 101-105. DOI: https://doi.org/10.15421/2020_16

12. Girka, A.D., Tkalich, ID, Sidorenko, Yu.Ya. [etc.]. (2018). Current aspects of pea growing technology in the northern steppe of Ukraine. *Bulletin of Agricultural Science, 2,* 31-35. DOI: https://doi.org/10.31073/agrovisnyk201802-05.

13. Chynchyk, O., Olifirovych, S., Olifirovych, V., Nebaba K. (2021). Biological Nitrogen in Increasing the Productivity of Beans (Grains). *UREKA: Life Sciences*, *5,* 12-17. DOI:10.21303/2504-5695.2021.002075.

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