UDC 635.652:631.847.211
CHYNCHYK O.S., CSc
Podilsky State Agricultural and Technical University
E-mail: chinchik1@mail.ru

SPECIFICS OF PHOTOSYNTHETIC PRODUCTIVITY FORMATION IN KIDNEY BEAN UNDER INFLUENCE OF ECOGRAN AND MINERAL FERTILIZERS

It was established that applying organic-mineral fertilizer Ecogran application on dynamics of leaf area formation, dry matter accumulation and net photosynthetic productivity of kidney bean in environment of the southern part of the Western Forest-Steppe. Application both Ecogran and fertilizers increased leaf area in kidney bean cultivars up to 37,200-38,700 m2/ha, dry matter yield to 6.15-6.36 t/ha and net photosynthetic productivity of the crops.
Keywords: *kidney bean; cultivar; mineral fertilizers; leaf area; dry matter; photosynthetic capacity; net photosynthetic productivity.*

Introduction. The original source of organic matter in crops is photosynthesis. It is therefore important to provide optimal conditions for developing and functioning of photosynthetic apparatus, which will ensure high productivity of kidney bean.

Photosynthesis and mineral nutrition make a system of plant nutrition. A purpose of positive effect of mineral nutrition is to increase the photosynthetic efficiency in plants [2]. Photosynthetic apparatus of kidney bean is continuously changing from germination to harvesting, reaching its peak in the period of budding – flowering [5]. The larger leaf area at optimum density is the higher photosynthetic capacity per unit area develops [4]. Biopreparations, in particular Ryzotorfin, have positive impact on increasing leaf area, net productivity of photosynthesis and photosynthetic capacity [3]. Yield formation in kidney bean directly depends on the net photosynthetic productivity. Application of Ryzotorfin as well as other biopreparations positively effects net photosynthetic productivity [1]. According to D. S. Shliakhturov [6], combination of biologically fixed nitrogen and mineral fertilizers in fertilizing practice provides better conditions for productivity formation in kidney bean.

Therefore, our goal was investigating effect of varietal features and different fertilization practice on the photosynthetic activity indices in kidney bean.

Materials and methods. The study was carried out during 2011-2013 in fodder crop rotation in a field of Podilsky State Agricultural and Technical University. Soil there is deep leached loamy chernozem on loess loam of small humus content. Experimental plot had following agrochemical indices (in the soil layer 0-30 cm): humus content of 4.34 %; pH 6.8; easily hydrolyzed nitrogen of 124 mg/kg of soil; mobile phosphorus of 86 mg/kg of soil; exchangeable potassium of 167 mg/kg soil. We studied the effect of organic fertilizer Ecogran on symbiotic productivity performance in kidney bean varieties. The fertilizer contains 70% of chicken manure, 6 % of gypsum, 6 % of K_2O, and 6% of P_2O_5. Moisture content is less than 12-14 %, grain size is 2-3.5 mm; nutrient content in dry matter: total nitrogen 3.6 %, phosphorus equivalent to P_20_5 3.6 %, potassium equivalent to K_20 3-6 %; microelement content (mg/kg): manganese100-280, zinc 90-290, copper 30-40, iron 270-700, cobalt 8-11; dry organic matter 55-65%.

The total sown area was 45.0 m^2, accounting area - 25.2 m^2; four replications. The subjects of research are kidney bean cultivars Nadia and Bukovynka. Leaf area was determined by a method of carving. Photosynthetic capacity and net photosynthesis productivity was calculated by the Nychyporovych method [2]. Technology of soil preparation, planting and crop tending were convenient for the area.

Results. The experiment carried out during 2011-2013 showed that leaf area in kidney bean was increasing from the three-leaf stage to flowering (its maximum fell on the end of flowering). We have determined the leaf area at all major stages of growth and development of kidney bean, but for the purpose of our experiment (studying effect of a cultivar, Ecogran and fertilizers) we primarily used this index at the end of flowering stage. Thus, in control variant (cultivar Nadia, without applying Ecogran and fertilizers) leaf area was 31,800 m^2/ha. When fertilizing ($N_{30}P_{60}K_{60}$) leaf area increased to 37,400 m^2/ha, that is higher by 5,600 m^2/ha as compared with the control variant (Table 1).

Table 1

Dynamics of leaf area formation in kidney bean subject to cultivar and fertilizing (thousand m^2/ha), average for 2011-2013

Variant		Phenological stage					
Cultivar	Fertilizing	Complete emergence – three-leaf	Three-leaf - budding	Budding - beginning of flowering	Beginning of flowering – end of flowering	End of flowering – grain forming	Complete emergence – beginning of ripening
Nadia	Control (no fertilizers)	6.9	13.2	18.3	31.8	27.9	6.2
	$N_{30}P_{60}K_{60}$ + Crystallon	7.4	15.8	22.9	37.4	31.1	6.3
	Ecogran (1.5 t/ha)	6.8	13.7	19.9	35.7	30.8	6.9
	Ecogran (1.5 t/ha) + Crystallon	6.9	14.0	20.5	36.1	31.6	7.0
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	7.3	16.0	23.7	37.2	32.0	6.5
Bukovynka	Control (no fertilizers)	6.5	12.9	18.1	32.6	28.7	5.9
	$N_{30}P_{60}K_{60}$ + Crystallon	6.8	16.1	22.4	38.0	32.5	6.1
	Ecogran (1.5 t/ha)	6.6	13.8	18.6	37.1	33.4	6.5
	Ecogran (1.5 t/ha) + Crystallon	6.5	13.6	18.9	37.5	32.9	6.3
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	6.8	15.9	21.7	38.7	33.6	6.8

Applying 1.5 g/ha of Ecogran also increased leaf area at the end of flowering stage to 35,700 m^2/ha. However, this figure was 1,700 m^2/ha less as compared with application of $N_{30}P_{60}K_{60}$. Simultaneous use of $N_{30}P_{60}K_{60}$ and 0.3 t/ha of Ecogran increased leaf area to 37,200 m^2/ha.

Leaf area in cultivar Bukovynka at the end of flowering in variant without fertilizing was 32,600 m^2/ha that is 800 m^2/ha more than in control variant. When applying mineral fertilizer $N_{30}P_{60}K_{60}$, indicator of assimilation area also rose to 38,000 m^2/ha, which exceeded the indicator in variant without fertilizing by 5,400 m^2/ha and that in control variant by 6,200 m^2/ ha.

With application of 1.5 t/ha of Ecogran leaf area increased by 4,500 m^2/ha as compared with the variant without fertilization, i.e. to 37,100 m^2/ha. The largest leaf area of 38,700 m^2/ha developed cultivar Bukovynka when applying $N_{30}P_{60}K_{60}$, 0.3 t/ha of Ecogran and Crystallon.

Thus, in environment of the southern part of the Western Forest-Steppe cultivar Bukovynka developed larger leaf area as compared with Nadia. Leaf area in kidney bean also significantly increased when applying mineral fertilizers and Ecogran.

We also determined the dynamics of dry matter on the stages of growth and development of kidney bean. It produced the maximum amount of dry matter during seed ripening. Cultivar Nadia gained 4.97 t/ha of dry matter in control variant (without fertilizing) (Table 2).

Fertilizer ($N_{30}P_{60}K_{60}$) contributed to increase in dry matter accumulation in cultivar Nadia to 6.07 t/ha, which was 1.1 t/ha more as compared with the control variant. When applying 1.5 t/ha of Ecogran the dry matter accumulation slightly decreased to 5.53 t/ha, that is 0.56 t/ha more as compared with the variant without fertilizing. The best fertilizing option to maximize dry matter accumulation appeared to be $N_{30}P_{60}K_{60}$ + 0.3 t/ha of Ecogran + Crystallon.

Table 2

Dynamics of dry matter accumulation in kidney bean subject to cultivar and fertilizing (t/ha), average for 2011-2013

Variant		Phenological stage					
Cultivar	Fertilizing	Complete emergence – three-leaf	Three-leaf - budding	Budding - beginning of flowering	Beginning of flowering – end of flowering	End of flowering – grain forming	Complete emergence – beginning of ripening
Nadia	Control (no fertilizers)	0.61	1.93	2.55	3.88	4.83	4.97
	$N_{30}P_{60}K_{60}$ + Crystallon	0.68	2.15	3,11	4.76	6.01	6.07
	Ecogran (1.5 t/ha)	0.63	2.02	2.,77	4.11	5.26	5.53
	Ecogran (1.5 t/ha) + Crystallon	0.59	2.09	2.85	4.26	5.43	5.71
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	0.67	2.21	3.15	4.69	6.03	6.15
Bukovynka	Control (no fertilizers)	0.55	1.82	2.67	4.02	4.91	5.12
	$N_{30}P_{60}K_{60}$ + Crystallon	0.64	2.07	3.22	4.85	6.03	6.18
	Ecogran (1.5 t/ha)	0.57	1.96	2.79	4.28	5.50	5.77
	Ecogran (1.5 t/ha) + Crystallon	0.59	1.99	2.84	4.32	5.94	6.09
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	0.68	2.03	3.16	4.93	6.21	6.36

Photosynthetic capacity of Nadia made up 1.31m m^2/ha per day in control variant (without fertilizing) (Table 3).

Table 3

Photosynthetic capacity of kidney bean crops subject to cultivar and fertilizing (million m^2 /ha per day), average for 2011-2013

Variant		Phenological stage					
Cultivar	Fertilizing	Complete emergence - three-leaf	Three-leaf - budding	Budding - beginning of flowering	Beginning of flowering – end of flowering	End of flowering – grain forming	Complete emergence – beginning of ripening
Nadia	Control (no fertilizers)	0.21	0.11	0.43	0.27	0.29	1.31
	$N_{30}P_{60}K_{60}$ + Crystallon	0.24	0.14	0.51	0.31	0.32	1.52
	Ecogran (1.5 t/ha)	0.22	0.12	0.47	0.30	0.32	1.43
	Ecogran (1.5 t/ha) + Crystallon	0.22	0.12	0.48	0.30	0.33	1.45
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	0.24	0.14	0.52	0.31	0.33	1.54
Bukovynka	Control (no fertilizers)	0.20	0.11	0.43	0.31	0.31	1.36
	$N_{30}P_{60}K_{60}$ + Crystallon	0.25	0.13	0.51	0.39	0.37	1.65
	Ecogran (1.5 t/ha)	0.21	0.11	0.47	0.39	0.39	1.57
	Ecogran (1.5 t/ha) + Crystallon	0.21	0.11	0.48	0.39	0.37	1.56
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	0.25	0.13	0.51	0.40	0.40	1.69

The highest photosynthetic capacity recorded when applying $N_{30}P_{60}K_{60}$, Crystallon and 0.3 t/ha of Ecogran and made up in cultivar Nadia 1.54m m^2/ha per day, in Bukovynka - 1.69m m^2/ha per day. Thus, in this particular region the development of photosynthetic capacity is more dependent on fertilizing practice than varietal characteristics.

One of the most important indicators of photosynthesis process is net photosynthetic productivity, i.e. the number of plastic substances per unit of leaf area (Table 4).

Table 4

Dynamics of net photosynthetic productivity of kidney bean crops subject to cultivar and fertilization (g/m^2 per day), average for 2011-2013

Cultivar	Fertilizing	Phenological stage				
		Complete emergence – third leaf	Third leaf - budding	Budding - beginning of flowering	Beginning of flowering – end of flowering	End of flowering – grain forming
Nadia	Control (no fertilizers)	6.3	5.6	3.1	3.5	0.5
	$N_{30}P_{60}K_{60}$ + Crystallon	6.0	7.1	3.2	4.1	0.2
	Ecogran (1.5 t/ha)	6.5	6.4	2.8	3.8	0.8
	Ecogran (1.5 t/ha) + Crystallon	6.8	6.3	2.9	3.8	1.3
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	6.3	6.8	3.0	4.3	0.4
Bukovynka	Control (no fertilizers)	6.2	7.8	3.1	2.9	0.7
	$N_{30}P_{60}K_{60}$ + Crystallon	5.7	8.5	3.2	3.0	0.4
	Ecogran (1.5 t/ha)	6.5	7.3	3.1	3.1	0.7
	Ecogran (1.5 t/ha) + Crystallon	6.6	7.5	3.1	4.2	0.4
	$N_{30}P_{60}K_{60}$ + Crystallon + Ecogran (0.3 t/ha)	5.4	8.6	3.4	3.2	0.4

We found that maximum of net photosynthetic productivity of kidney bean crops fell into periods of three leaf - budding and of budding - beginning of flowering.

Conclusions. Application both fertilizers and Ecogran significantly increased leaf area in kidney bean. Maximum assimilation area (36,100-38,700 m^2/ha) was observed at the end of flowering when applying $N_{30}P_{60}K_{60}$ + Crystallon + 0.3 t/ha of Ecogran. The most intensive accumulation of dry matter during growing season recorded Bukovynka at the fertilization scheme described above - 6.36 t/ha. Net photosynthetic productivity varied in different phases of growth, reaching its peak in the period of three leaf-beginning of flowering. The maximum value of photosynthetic capacity of 1.69m m^2/ha per day provided cultivar Bukovynka.

References

1. Белоброва С.Н. Продуктивность фасоли обыкновенной (*Phaseolus vulgaris* L.) при обработке семян микробными препаратами: автореф. дис. на соискание научной степени канд. с.-х. наук: спец. 06.01.01 «Общее земледелие» / С.Н. Белоброва. – СПб, 2012. – 20 с.

2. Фотосинтетическая деятельность растений в посевах / [А.А. Ничипорович, Л.Е. Строганова, С.Н. Чмора, М.П. Власова]. – М.: Издательство АН СССР, 1961. – 135 с.

3. Роль биопрепаратов в повышении симбиоза и продуктивности фасоли / [Н.В. Парахин, Т.С. Наумкина, А.А. Осин та ін.] // Вестник ОрелГАУ : Теоретический и научно-практический журнал. – 2008. – № 4 (13). – С. 2-4.

4. Стаканов Ф.С. Фасоль / Ф.С. Стаканов. – Кишинев: Штииница, 1986. – 195 с.

5. Тихончук П.В. Фотосинтетическая деятельность и урожай фасоли обыкновенной в зависимости от передпосевной обработки семян / П.В. Тихончук, А.А. Муратов // Аграрный вестник Урала : Всероссийский научный аграрный журнал. – 2008. – № 6 (48). – С. 42-44.

6. Шляхтуров Д.С. Урожайність квасолі звичайної залежно від технології вирощування і погодних умов / Д.С. Шляхтуров // Збірник наукових праць ННЦ «Інститут землеробства УААН». – К.: ВД «ЕКМО», 2008. – Вип. 3-4. – С. 85-89.

Анотація

Чинчик О.С.

Особливості формування показників фотосинтетичної продуктивності квасолі звичайної під впливом екограну і мінеральних добрив

За результатами трирічних досліджень показано вплив використання органо-мінерального добрива екогран на динаміку формування листкової поверхні, накопичення сухої речовини та динаміку чистої продуктивності фотосинтезу посівів квасолі звичайної в умовах південної частини Лісостепу західного. Встановлено, що внесення екограну і мінеральних добрив збільшувало площу листкової поверхні сортів квасолі звичайної до 37,2-38,7 тис. $м^2$ га, вихід сухої речовини до 6,15-6,36 т/га та підвищувало чисту продуктивність фотосинтезу посівів культури.

Ключові слова: *квасоля звичайна, сорт, екогран, мінеральні добрива, листкова поверхня, суха речовина, фотосинтетичний потенціал, чиста продуктивність фотосинтезу*

Аннотация

Чинчик А.С.

Особенности формирования показателей фотосинтетической продуктивности фасоли обыкновенной под влиянием Экограна и минеральных удобрений

По результатам трехлетних исследований показано влияние использования органоминерального удобрения Экогран на динамику формирования листовой поверхности, накопления сухого вещества и динамику чистой продуктивности фотосинтеза посевов фасоли обыкновенной в условиях южной части западной Лесостепи. Установлено, что внесение Экограна и минеральных удобрений увеличивало площадь листовой поверхности сортов фасоли обыкновенной до 37,2-38,7 тыс. $м^2$/га, выход сухого вещества до 6,15-6,36 т/га и повышало чистую продуктивность фотосинтеза посевов.

Ключевые слова: *фасоль обыкновенная, сорт, Экогран, минеральные удобрения, листовая поверхность, сухое вещество, фотосинтетический потенциал, чистая продуктивность фотосинтеза*