

**INFLUENCE OF GROWING TECHNOLOGY ELEMENTS ON BIOMETRIC INDICATORS
AND INDIVIDUAL PRODUCTIVITY OF COMMON BEAN (*PHASEOLUS VULGARIS* L.) PLANTS
UNDER CLIMATIC CHANGES IN THE FOREST-STEPPE OF UKRAINE**

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Topicality. One of the priority areas of scientific research in the field of crop production is the substantiation and improvement of modern cultivation technologies for grain legumes based on energy and resource conservation and environmental safety. A comprehensive study of agrobiological characteristics and elements of cultivation technology is a prerequisite for the efficient utilisation of the biological potential of varieties and the increase of individual and grain productivity of common bean plants. Nowadays, the issues of theoretical and practical aspects of common bean cultivation technologies under climate change in the Forest-Steppe of Ukraine are particularly important, as they would ensure the creation of optimal conditions for its growth, development and formation of maximum grain productivity. **Purpose.** Investigation of the impact of cultivation technology elements on biometric parameters and individual productivity of common bean plants in the Forest-Steppe of Ukraine. **Methods.** Field method (laying out experiments, phenological observations and records), measuring and weighing (determining yield attributes), statistical (mathematical processing of research results). **Results.** It was found that the best development and individual productivity of common bean plants in the agroclimatic conditions of the Forest-Steppe were on wide-row crops (row spacing of 45 cm). The tendency to decrease biometric parameters of plants with increasing planting density is observed. The highest values of yield attributes of common bean were obtained on wide-row crops at the first sowing date (11–14 May). The highest grain weight per plant was obtained in the crops of the first sowing date at plant density of 450,000 plants/ha (22.6 g in Mavka variety and 23.7 g in Panna variety). The lowest value was observed on conventional row crops (15 cm) with a plant density of 750,000 plants/ha (14.5 g and 13.5 g, respectively). The highest 1000 grain weight was obtained in wide-row crops at the first sowing date (212–217 g in Mavka variety and 329–341 g in Panna variety). **Conclusions.** Sowing methods and dates, plant densities significantly affect the biometric parameters and individual productivity of common bean plants. The variation of these parameters depends on the genotype of plants of a particular variety. The highest individual plant productivity is achieved with wide-row sowing at the first sowing date with a plant density of 450,000 plants/ha. The number of grains and their weight per plant corresponded to the varietal characteristics of each sample.

Key words: common bean, sowing method, plant density, sowing date, biometric indicators, individual productivity

Introduction. One of the most important indicators of the living standards of the population of any country is the amount of protein consumed by humans. In the context of reforming the Ukrainian agro-industrial complex and reducing the production of animal products, the production of high-protein crop products has become important [1, 2].

The shortage of vegetable protein, the focus of production on environmentally friendly crops, and the high cost of mineral and organic fertilisers are driving the growing interest in leguminous crops [3].

In the current development of agricultural production, the priority area of scientific research is the substantiation and improvement of modern agricultural technologies for growing legumes according to the principles of energy and resource conservation and environmental safety [4, 5].

Today, considerable attention in solving the problem of protein deficiency is paid to common beans as a source of amino acid-balanced, cheap and environmentally friendly protein [6].

Beans are a valuable high-protein crop that has a wide range of uses in the national

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economy. In many countries, beans are the main source of protein close to animal proteins [7, 8]. Beans are cultivated on about 23–25 million hectares in the world's agriculture. Among legumes, they are the second most important crop after soybeans and are in great demand, especially as a food crop [9]. Beans are a traditional crop in Ukraine. Long frost-free periods and rich chernozem soils allow for high grain yields. At the same time, the cultivated area under the crop, as well as seed yields, continue to be insignificant. Beans are grown mainly on private plots, although the crop is in high demand on the global market with consistently high prices [10, 11].

Beans have a high nutritional value. It contains proteins (20–25 %), carbohydrates (60 %), potassium, calcium, sulphur, magnesium, phosphorus, iron, and vitamins B₁, B₂, B₃, B₆, C, E, K and PP. The energy value of a bean grain is 333 kcal (+1393 kJ). The bean protein is absorbed by 70–80 % and is superior to many types of meat in terms of nutritional value. Beans are a valuable foodstuff that does not lose its nutritional qualities when stored for several years. In addition, they are used in animal feeding and in pharmaceuticals to make medicines. Therefore, beans have a wide range of applications in the national economy [12, 13].

Beans also play an important agronomic role. Beans are an inexhaustible source of soil enrichment with nitrogen compounds due to nitrogen fixation by nodule bacteria in symbiosis with plants. Growing beans allows reducing the cost of crop production by including atmospheric nitrogen in the agricultural production process, improving the phytosanitary condition of crops and significantly increasing arable land productivity [14–16].

Rapid global climate changes significantly increase the risks of agricultural production. In this regard, society is facing the challenge of modernising the traditional model of agricultural production in view of global climate change [4, 17].

At present, the issues of theoretical and practical aspects of cultivation technologies under climate change in the Forest-Steppe zone, which would ensure the optimal conditions for the growth, development and formation of maximum grain productivity of legumes, are insufficiently studied. Therefore, the development of new models and improvement of existing ones of common bean cultivation technology, in particular on the basis of optimising conditions for *Grain Crops*. Vol. 8. No. 2. 2024. P. 244–250

increasing the activity of biological nitrogen fixation, is an essential issue today [2].

The plant growth and development and the formation of their productivity are important factors that characterise the production process of agricultural crops, in particular, common beans. The intensity of growth and development directly increases plant productivity [18].

For increasing the individual and grain productivity of plants, an important element of cultivation technology is the optimal spatial and quantitative arrangement of plants, which is determined by the methods of sowing and the plant density in the crop. There are different points of view on the issue of spatial arrangement of plants, which is based on different soil and climatic conditions of their cultivation [19, 20].

Effective realisation of the biological potential of bean varieties in the soil and climatic conditions of the Forest-Steppe requires the development and implementation of new adaptive cultivation technologies with consideration of the variety genotype. A comprehensive study of agrobiological features and cultivation technology of beans is a prerequisite for high productivity indicators and increased grain production [4].

The study is aimed at investigating the influence of cultivation technology elements on biometric parameters and individual productivity of common bean plants in the Forest-Steppe of Ukraine.

Materials and Methods. The study was conducted at the Research Station of Tobacco Production of the National Scientific Centre 'Institute of Agriculture of NAAS' during 2021–2023.

We used two domestic varieties of common bean Mavka and Panna developed by the National Scientific Centre 'Institute of Agriculture of NAAS'. Beans were sown in two dates (II and III ten-day periods of May). Beans were sown on 11–14 May for the first sowing date and on 26–29 May for the second one, using situational weather conditions. Wide-row (row spacing of 45 cm) and conventional row (row spacing of 15 cm) sowing methods were used with plant density of 350, 450 and 650, 750 thousand seeds/ha, respectively. The soil of the experimental field was podzolic chernozem with a humus content of 3.31 % in the topsoil (0–30 cm). The area of the registration plot was 8 m²; the trial was repeated three times. Studies of the technological features in common bean cultivation <https://doi.org/10.31867/2523-4544/0338> 245

technology carried out in accordance with generally accepted methods in crop production [21, 22].

Results and Discussion. Studies in 2021–2023 found that the Mavka variety had a higher plant height compared to Panna variety. The plant height of Mavka variety on wide-row crops at the first sowing date varied within 54.8–55.6 cm, at the second date – 55.8–56.5 cm (Table 1). At sowing with a row spac-

ing of 15 cm, these indicators were 53.5–53.6 cm and 53.1–53.2 cm, respectively.

In Panna variety, the plant height in wide-row crops of the first sowing date was within 51.3–53.0 cm, and in the second one – 53.6–53.7 cm. In the crops with a row spacing of 15 cm, the corresponding indicators were 47.7–48.1 cm and 47.7–49.3 cm, respectively.

A significant effect of the variety geno-

Table 1. Characteristics of biometric parameters of common bean plants depending on the cultivation technology elements, average for 2021–2023

Sowing method (factor C)	Plant density, ths. plants/ha (factor A)	Plant height, cm		Stem diameter, cm		The lowest pod height, cm	
		I (B)	II (B)	I	II	I	II
Mavka variety (factor A)							
Wide-row, 45 cm	350	54.8	56.5	0.73	0.68	21.6	22.9
	450	55.6	55.8	0.72	0.67	22.5	23.3
Conventional row, 15 cm	650	53.6	53.1	0.69	0.66	20.2	20.7
	750	53.5	53.2	0.66	0.61	20.1	24.4
Average		54.4	54.7	0.70	0.66	21.1	22.8
Panna variety (factor A)							
Wide-row, 45 cm	350	51.3	54.0	0.69	0.64	22.6	24.6
	450	53.0	53.6	0.70	0.69	23.6	24.4
Conventional row, 15 cm	650	47.7	47.7	0.64	0.62	23.4	23.3
	750	48.1	49.3	0.60	0.61	23.8	23.8
Average		50.0	51.1	0.66	0.64	23.4	24.0
<i>LSD₀₅ by factor A (variety)</i>		2.6–2.8		0.03		1.0–1.2	
<i>LSD₀₅ by factor B (sowing dates)</i>		2.9–3.1		0.03		1.2–1.4	
<i>LSD₀₅ by factor C (sowing methods)</i>		2.8–3.0		0.02		1.1–1.3	
<i>LSD₀₅ by factor D (plant density)</i>		2.7–2.9		0.03		1.1–1.3	

Notes. I (B) – the first sowing date is 11–14 May, II (B) – the second sowing date is 26–29 May.

type on plant height was proved for both sowing methods at the first sowing date. At the second date, the impact of the variety genotype was observed only in variants with conventional row sowing (650 and 750 thousand seeds/ha) in Panna variety.

There was no significant effect of sowing method on plant height in Mavka variety at both dates. At the same time, the significant effect of this factor was found on plant height in Panna variety under the same conditions. Plant nutrition areas had a slight effect on plant height in most variants within a certain sowing method.

The stem diameter of Mavka plants in wide-row crops of the first sowing date averaged 0.73 cm, in the second one – 0.67 cm, and in Panna variety – it was 0.70 cm and 0.67 cm, respectively. This indicator on conventional crops for Mavka variety was 0.68 cm and 0.64 cm, for Panna variety – 0.62 cm and 0.61 cm,

respectively. The most significant effects on the stem diameter of the studied factors were the plant density, sowing dates and genotype of the variety.

In general, there is a tendency for the stem diameter of plants to decrease with increasing plant density. This is primarily explained by the plant nutrition area and, accordingly, changes in their architectonics.

The decrease in the stem diameter of bean plants under the second sowing date is explained by higher air temperature during their ontogeny and lower soil moisture availability.

An important trait of common bean cultivation is the lowest pod height on the stem. It plays a key role in mechanised harvesting of the beans. The lowest pod height is a highly variable trait, which is determined by both the genetic characteristics of the plants of a particular variety and the growing conditions. In general,

there is a tendency to increase the lowest pod height with increasing plant density.

The lowest pod height in both varieties was higher at the second sowing date. The lowest pod height in Mavka variety at both sowing methods varied within 20.1–22.5 cm at the first sowing date and 20.7–24.4 cm at the second one; for Panna variety – 22.6–23.8 cm and 23.3–24.6 cm, respectively. The greatest impact

on the manifestation of this trait was the genotype of the variety, sowing methods and plant density.

According to the results of the research in 2021–2023, the plants of Panna variety had a longer pod length (Table 2). This is primarily due to the genotypic characteristics of common bean varieties.

The pod length of Mavka and Panna varie-

Table 2. Pod length and width of common bean, 2021–2023

Sowing method (factor C)	Plant density, ths. plants/ha (factor D)	Pod length, cm		Pod width, cm	
		I (factor B)	II (factor B)	I	II
Mavka variety (factor A)					
Wide-row, 45 cm	350	9.9	10.0	0.90	0.88
	450	9.8	10.0	0.89	0.88
Conventional row, 15 cm	650	9.6	9.9	0.89	0.88
	750	9.5	9.7	0.88	0.86
Average		9.7	9.9	0.89	0.88
Panna variety (factor A)					
Wide-row, 45 cm	350	13.3	13.1	0.92	0.88
	450	13.4	13.3	0.94	0.91
Conventional row, 15 cm	650	12.6	12.7	0.91	0.87
	750	12.9	12.6	0.92	0.87
Average		13.1	12.9	0.92	0.88
<i>LSD₀₅ by factor A (variety)</i>		0.4–0.5		0.04–0.06	
<i>LSD₀₅ by factor B (sowing dates)</i>		0.5–0.6		0.05–0.07	
<i>LSD₀₅ by factor C (sowing methods)</i>		0.4–0.6		0.04–0.07	
<i>LSD₀₅ by factor D (plant density)</i>		0.4–0.5		0.05–0.08	

Notes. I (B) – the first sowing date is 11–14 May, II (B) – the second sowing date is 26–29 May.

ties did not change significantly depending on the sowing dates. The pod length in Mavka variety averaged 9.7 cm at the first sowing date and 9.9 cm at the second, while for Panna variety – 13.1 cm and 12.9 cm, respectively. The sowing method significantly affected this indicator in Panna variety. The pod length was 13.3–13.4 cm in wide-row crops and 12.6–12.9 cm in conventional crops at the first sowing date, and 13.1–13.3 cm and 12.6–12.7 cm at the second sowing date, respectively. Primarily, this was caused by the nutrition area of individual plants and their architectonics. In the Mavka variety, no significant effect of the sowing method on this indicator was observed. The effect of plant density on the pod length at different sowing methods was insignificant.

The pod width of common bean did not differ significantly at both sowing dates and averaged 0.89 cm and 0.88 cm in Mavka variety and 0.92 cm and 0.88 cm in Panna variety, res-

pectively. The impact of genotype and sowing method on the manifestation of this trait was insignificant.

The formation of common bean grain yield is determined by two indicators: plant density and individual plant productivity. Individual plant productivity shows the effect of the studied factors on the realisation of the biological potential of the variety [2].

The number of pods per plant averaged 18.7 at the first sowing date, 16.6 at the second sowing date in Mavka variety as well as 15.9 and 15.1 pods in Panna variety, respectively (Table 3). It was found that the number of pods per plant was lower at the second sowing date compared to the first. Higher indicators were obtained on wide-row crops at the first sowing date (20.7–20.8 pods in Mavka variety and 17.0–19.8 pods in Panna variety). Sowing methods and plant density had the greatest impact on the number of pods per plant.

For wide-row sowing method, the number of grains per pod was 6.2–6.3 in Mavka variety

Table 3. Yield attributes depending on the technological features of the cultivation, 2021–2023

Sowing method	Plant density, thsd plants/ha	Number of pods per plant, pcs.		Number of grains per pod, pcs.		Number of grains per plant, pcs.		Weight of grains per plants, g		1000 grain weight, g	
		Sowing dates									
		I	II	I	II	I	II	I	II	I	II
Mavka variety											
Wide-row, 45 cm	350	20.8	18.4	6.2	6.2	99.5	92.6	21.3	18.4	212	207
	450	20.7	18.5	6.3	6.3	94.1	93.8	22.6	18.9	217	205
Conventional row, 15 cm	650	17.9	15.2	5.7	6.0	84.2	81.4	18.7	17.0	200	199
	750	15.3	14.3	5.5	5.9	72.6	68.0	14.5	14.3	202	203
Average		18.7	16.6	5.9	6.1	87.6	84.0	18.6	17.2	208	204
Panna variety											
Wide-row, 45 cm	350	17.0	16.6	4.7	4.7	66.9	57.7	19.3	17.3	341	301
	450	19.8	19.7	4.8	5.0	76.5	71.7	23.7	20.9	329	300
Conventional row, 15 cm	650	13.9	11.8	4.5	4.5	50.3	43.6	15.5	12.9	318	292
	750	12.7	12.2	4.4	4.4	43.5	44.0	13.5	12.4	327	281
Average		15.9	15.1	4.6	4.7	59.3	54.3	18.0	15.9	329	294
<i>LSD₀₅ by factor A</i>		0.7–0.8		0.4		4.1–4.4		0.6–0.8		12.8–13.4	
<i>LSD₀₅ by factor B</i>		0.9–1.0		0.3		3.8–4.0		0.7–0.9		12.2–12.9	
<i>LSD₀₅ by factor C</i>		0.9–1.1		0.3		4.2–4.4		0.6–0.9		11.7–12.4	
<i>LSD₀₅ by factor D</i>		1.0–1.2		0.4		3.9–4.2		0.8–0.9		12.1–13.0	

Notes. I – the first sowing date is 11–14 May, II – the second sowing date is 26–29 May.

and 4.7–5.0 in Panna variety. For the conventional sowing method, these indicators were in the range of 5.5–6.0 grains and 4.4–4.5 grains per pod. The largest number of grains per pod (6.3) was in Mavka variety in the variant of the experiment with wide-row sowing with a plant density of 450,000 plants/ha.

The number of grains per plant of Mavka variety varied within 92.6–99.5 grains in wide-row crops and 68.0–84.2 grains in conventional crops. The maximum values of this indicator were obtained on wide-row crops at the first sowing date with plant density of 350,000 plants/ha. In Panna variety, the corresponding indicator was in the range of 57.7–76.5 grains per plant on wide-row crops and 43.5–50.3 grains per plant on conventional crops. The largest number of grains per plant was obtained in wide-row sowing with a plant density of 450,000 plants/ha (76.5 grains), the smallest – in conventional sowing with a plant density of 750,000 plants/ha (43.5 grains).

It was found that a greater mass of grains per plant was obtained on wide-row crops. Thus, Mavka variety had 21.3–22.6 g at the first sowing date and 18.4–18.9 g at the second one. On conventional crops, this indicator was 14.5–

18.7 g and 14.3–17.0 g, respectively. Panna variety had the grain weight per plant in the range of 19.3–23.7 g and 17.3–20.9 g on wide-row crops, and 13.5–15.5 g and 12.4–12.9 g on conventional crops, respectively. The maximum values were obtained in the first sowing date at a plant density of 450,000 plants/ha (22.6 g in Mavka variety and 23.7 g in Panna variety). The lowest grain weight per plant was observed in conventional crops with plant density of 750,000 plants/ha. The significant influence of the variety genotype, sowing method and plant density on the manifestation of this trait was established.

One of the most important indicators of the yield attributes of a crop is the 1000 grain weight. This trait is inherited quite stably and is directly related to the yield of the variety. The 1000 grain weight was on average 208 g in the Mavka variety at the first sowing date and 204 g at the second one, and 329 g and 294 g in Panna variety, respectively. The highest values were obtained in wide-row crops (212–217 g in Mavka variety and 329–341 g in Panna variety) at the first sowing date. This trait is primarily related to the genetic characteristics of the variety and is stably maintained within the specified

parameters during its reproduction. However, weather conditions and elements of cultivation technology affect the manifestation of this trait, which must be taken into account when growing common beans.

Conclusions. It was found that methods and terms of sowing, plant density significantly affect the biometric parameters and individual productivity of common bean plants. The varia-

tion of their manifestation is within the parameters determined by the genotype of a particular variety. The highest individual productivity of plants is achieved on wide-row crops (45 cm) of the first sowing date (11–14 May) at a plant density of 450,000 plants/ha. The number of grains per plant and their absolute weight corresponded to the varietal characteristics of each sample.

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Парфенюк О. О., Труш С. Г., Баланюк Л. О. Вплив елементів технології вирощування на біометричні показники та індивідуальну продуктивність рослин квасолі звичайної (*Phaseolus vulgaris* L.) в Лісостепу України. *Зернові культури*. 2024. 8 (2). 244–250.

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Актуальність. Одним з пріоритетних напрямків наукових досліджень у галузі рослинництва є обґрунтування та удосконалення сучасних технологій вирощування зернобобових культур на засадах енерго- і ресурсозбереження та екологічної безпечності. Всебічне вивчення агробіологічних особливостей та елементів технології вирощування є необхідною умовою для ефективного використання біологічного потенціалу сортів і підвищення індивідуальної та зернової продуктивності рослин квасолі звичайної. Нині особливо важливими є питання теоретичних і практичних аспектів технологій вирощування квасолі звичайної за кліматичних змін у зоні Лісостепу України, які б забезпечили створення оптимальних умов для її росту, розвитку та формування максимальної зернової продуктивності. **Мета.** Дослідження впливу елементів технології вирощування на біометричні показники та індивідуальну продуктивність рослин квасолі звичайної в умовах Лісостепу. **Методи.** Польовий (закладання дослідів, фенологічні спостереження і обліки), вимірювально-ваговий (визначення елементів структури врожаю), статистичний (математична обробка отриманих результатів досліджень). **Результати.** Установлено, що в агрокліматичних умовах Лісостепу кращий розвиток та індивідуальна продуктивність рослин квасолі звичайної були на широкорядних посівах (45 см). Простежується тенденція до зменшення біометричних показників рослин зі збільшенням густоти насаджень. Вищі значення елементів структури врожаю рослин квасолі звичайної отримали на широкорядних посівах першого строку сівби (11–14 травня). Найбільшу масу зерна з рослини одержано на посівах першого строку за густоти насаджень 450 тис.шт./га (22,6 г – у сорту Мавка і 23,7 г – у сорту Панна). Найнижчі значення маси зерна були на звичайних рядкових посівах (15 см) з густотою насаджень 750 тис.шт./га (14,5 г і 13,5 г, відповідно). Більшу масу 1000 насінин отримано на широкорядних посівах першого строку сівби (212–217 г – у сорту Мавка і 329–341 г – у сорту Панна). **Висновки.** Способи і строки сівби, густина насаджень суттєво впливають на біометричні показники та індивідуальну продуктивність рослин квасолі звичайної. Варіювання їхнього прояву знаходиться в межах параметрів, обумовлених генотипом рослин певного сорту. Найвища індивідуальна продуктивність рослин досягається на широкорядних посівах першого строку сівби за густоти насаджень 450 тис.шт./га. Кількість зерен з рослини та їх маса відповідали сортовим характеристикам кожного зразка.

Ключові слова: квасоля звичайна, спосіб сівби, густина насаджень, строки сівби, біометричні показники, індивідуальна продуктивність