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THE INFLUENCE OF TECHNOLOGICAL FACTORS ON GROWTH, DEVELOPMENT AND YIELD OF COMMON BEAN VARIETIES

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ABSTRACT

The article shows the results of research on high-yielding varieties of common bean (*Phaseolus vulgaris* L.), growth and development of plants under the conditions of western forest-steppe. Moreover, it establishes the duration of the vegetation period, formation of elements of bean plant productivity that provides the appropriate level of seed yield, which depends on the cultivar and sowing methods. Sowing in the usual way with wide row spacing of 15 cm provided the highest yield of Mavka variety on the level of 1.78 t·ha⁻¹. As a result of sowing in the usual way with wide row spacing of 30 cm Bukovynka variety had the highest yield – 1.72 t·ha⁻¹, and as a result of the wide-row planting method with wide row spacing of 45 cm it was – 1.76 t·ha⁻¹.

Introduction

The main objective of agriculture in Ukraine at the present stage is to obtain production with limited expenditure of human energy and to protect the environment against degradation and pollution. One solution is to introduce new varieties, agricultural lands, which due to a considerable adaptive capacity provide a high level of implementation performance with minimal energy costs and provide a positive biogeocenotic impact on the elements of soil fertility.

The cultivation and consumption of beans in Ukraine have become popular. Low production of high-protein foods of animal origin, their high cost, gives impetus to increase the area under leguminous crops (Polyanskaja, 1991; Ovcharuk, 2013). For effective use of the biological potential of the varieties of beans and soil-climatic conditions of forest-steppe, it is important to develop and introduce into production a new adaptive varietal growing technology. Therefore, only a comprehensive study of agro-biological characteristics and technologies of cultivation of beans, establishment of conditions for obtaining high productivity, increases the seed production.

The growth and development of plants and the formation of their productivity are important indicators that characterize the production process of agricultural crops, in particular common beans (Kaminski, 2006; Petrechenko, 2003; Ovcharuk, 2013). The intensity of the growth processes is directly proportional to increases of the productivity of legumes

(Petrechenko, 2003). In turn, the intensification of the processes of growth and development is caused by the influence of environmental and biotic factors (Avadenyi, 2013; Ovcharuk, 2013; Petrechenko, 2003). However, the dominant role belongs to the varieties and growing techniques (Avadenyi, 2013; Golohorinska, 2005; Stakanov, 1986). Technological measures, which play an important role in shaping the productivity of legumes under favorable interaction unregulated factors, can reach 85% or more (Kaminski, 2006). Unlike technological activities, the role of the varieties as one of the most accessible and effective means of production is constantly growing and its contribution, according to the latest years, to the yield increase is estimated at 30-50% (Avadenyi, 2013; Golohorinska, 2005).

The objective of the research

The objective of the research was to set the duration of the phenological growth stages and development of bean and harvest patterns, depending on the variety in the western forest-steppe.

Methodology and source material research

Experimental studies were conducted within 2009-2013 on the experimental field of Podilsky State Agrarian Technical University.

The soil was deep black soil humus. The humus content (by Turin) in the topsoil was 3.4-3.8%, easily hydrolyzed nitrogen (by Kornfeld) amounted to – 10.5-12.2 mg 100 g⁻¹ of soil, mobile phosphorus (by Chirikov) – 16.5 mg 100 g⁻¹ of soil, potassium (by Chirikov) – 21.0 mg 100 g⁻¹ soil, pH (salt) – 7.3.

The climatic conditions in the western forest-steppe are characterized by a sufficient amount of heat, but unstable moistening. A significant temperature increase is observed during March-April and April-May. Summer is characterized by high and stable temperature. In July it is 20°C, in August 22-23°C. The warm period ranges from 230 to 265 days, and the period of active vegetation (temperature above 10°C) ranges from 155 to 170 days. The sum of active temperatures is 2300-2750°C, SCC reaches 1.3-2.0, annual rainfall varies from 498 to 675 mm in the West to 790 mm, the average air temperature of 7.8°C.

Sowing of common beans is held in the first decade of May. The total area of the plot was 45.0 m².

A brief description of the investigated varieties

Kharkivska shtambova. It is cultivated in Kharkiv Institute of Mechanization and Electrification of Agriculture by weight selection of early non-selective forms of 80-189. Its kind is ellipticus, albus. Plants are clustered, compact shaped, with a height of 40-60 cm. The flower is white. The height of attachment of the lower bean is 12-20 cm. Beans are resistant to cracking. The seeds are white, elliptical, smooth, shiny with hem in white. The weight of 1000 seeds is 245, the protein content in the seed is up to 23.6%. It boils well and has high gustatory properties. It is cold-resistant and suitable for mechanized harvesting. The duration of the vegetation period is 79-90 days. Seeds yield is 16-20 q·ha⁻¹ (Polyanskaja, 1991).

Mavka. Bred in the Institute of Agriculture of NAAS. Plant height is 50-60 cm. The height of attachment of the lower bean is 12-14 cm. It has many leaves. Plants are an indeterminate growth type, with a curling top and a straight form of a bush. Botanical variety is

var. ellipticus, albus. The under-cotyledon knee is light green, flowers are white, beans are yellow, with a pointed tip, the shape of the seed – oval-elliptic, the color of the seed coat is white, with a faint marble pattern. Weight of 1000 seeds is 280 g. Duration of the vegetation period is 105 days. The seeds contain 23% of protein.

This variety is of seed direction usage, it is resistant to lodging. Seeds are very tasty, resistant to shattering and suitable for mechanical harvesting. Seeds yield is 26 to 28 q·ha⁻¹. It is recommended for cultivation in the Steppe and in Polissya of Ukraine (Ovcharuk, 2013).

Nadiya. It is bred in Bukovina Institute of agro-UAAS. It was created by individual selection from a hybrid combination of Belcka 16×Pervomaiska. Kind-ellipticus, albus. The form of the stem – sectional. Plant height is 45-50 cm. Flowers are white. The height of attachment of the lower bean is 15-18 cm. Beans are resistant to cracking. The seeds are white, elliptical, smooth, shiny with white hem. The weight of 1000 seeds – 226-234 g, the protein content in the seeds is up to 26%. It boils well and has a high gustatory properties. The variety is of seed direction usage, cold-resistant and suitable for mechanized harvesting. The duration of the vegetation period 80-85 days. Seeds yield is 23-27 q·ha⁻¹ (Golohorinska, 2005; Ovcharuk, 2013).

Bukovynka. Bred in Bukovina Institute of agro-UAAS. Created by individual selection from a hybrid combination of Aluna×Alpha. Variety – ellipticus, albus. The form of the stem – sectional, secondary branching. Plant height is 50-55 cm. Flower is white, 2-6 in the brush. The height of attachment of the lower bean is 15-17 cm. Beans are resistant to cracking. The seeds are white, elliptical, smooth, shiny with white hem and the weight of 1000 seeds amount to 233-246 g. The content of protein in seeds – 26%. It boils well. The variety is of seed direction usage. The duration of the vegetation period is 80-85 days. The expected yield of seeds is 26.3-26.7 q·ha⁻¹ (Ovcharuk, 2013).

Podolyanochka. It is bred in Podilsky State Agrarian Technical University. It was created by individual selection from the local population. Variety - ellipticus, albus. The form of the stem - sectional. Plant height is 55-58 cm. Flower is white, 2-6 in the brush. The height of attachment of the lower bean is 12-15 cm. Beans are resistant to cracking. The seeds are white, elliptical, smooth, shiny with white hem. The weight of 1000 seeds is 230-245 g. The protein content in the seeds is 25-26%. It boils well. It has the grade of the seed direction; it is cold-resistant, suitable for mechanized harvesting. The duration of the vegetation period is 80-85 days. The expected yield of seeds is 26.5-27.0 q·ha⁻¹ (Ovcharuk, 2013).

The results of the research

The length of the growing period of crops is a genetically determined trait. An important feature of annual crops is a response to the changing environmental factors. It may be varied with regard to the variety, which is associated with such factors as: the group maturity, type of growth and others. Growing of common beans in a specific soil-climatic zone is important in the duration of the growing period (Golohorinska, 2005; Kaminski, 2006).

A variety and the sowing methods determine the duration of interphase periods in the ontogeny of plants and vegetation period in general. But, it is clear that even varieties of the same group of ripeness have different vegetation periods, due to the genetic characteristics of the variety (hybrid).

The research established that the growth and development of plants of different varieties during the growing period were held simultaneously. There are some differences in the

passage of the interphase periods. The study of interphase periods of development showed that the growing conditions affect the rate of passage stages of plant development of common beans. On average during the years of the research period, sowing-germination lasts for 10-12 days. Period of budding-flowering accounted for 10-13 days, flowering-ripening of beans – 21-23 days.

Therefore, we have analyzed the dynamics of the formation of the vegetation periods for each variety, and with regard to the sowing methods. In particular, the variety of Kharkivska shtambova growing period varied depending on the sowing methods from 75 to 81 days. (table 1).

Table 1
Effect of sowing methods on the duration of interphase periods in varieties of beans (average over 2009-2013)

Varieties	Interphase period (days)					Duration of vegetation period, days
	Shrouts to first trigeminal	First leaf trigeminal leaf-budding	Budding -flowering	Flowering-ripening beans	Pouring beans-technical ripeness	
Ordinary method of sowing (inter-row spacing of 15 cm)						
Kharkivska shtambova	10	16	10	21	18	75
Nadiya	11	18	11	21	20	81
Bukovinka	10	17	10	21	19	77
Mavka	11	19	12	23	20	85
Podolyanochka	10	18	11	21	20	81
Ordinary method of sowing (inter-row spacing of 30 cm)						
Kharkivska shtambova	10	16	11	22	19	78
Nadiya	11	18	10	22	21	82
Bukovinka	11	19	11	22	20	83
Mavka	11	20	12	23	21	87
Podolyanochka	10	20	12	22	20	84
Wide-row method of sowing (inter-row spacing of 45 cm)						
Kharkivska shtambova	10	18	12	21	20	81
Nadiya	12	19	11	22	21	85
Bukovinka	11	19	12	23	22	87
Mavka	12	20	13	24	22	91
Podolyanochka	11	20	12	23	21	87

The longest period of vegetation was obtained by sowing with a wide-row method, and the shortest growing period by sowing with the usual string method with wide row spacing of 15 cm.

The indicators characterizing the structural elements of plants, namely, plant height and attachment of the lower bean, the number of internodes and branches depend not only on the varietal, but also on sowing methods for different widths of rows (table 2).

Table 2
Characteristic of plants of beans depending on the varieties and sowing methods (average over 2009-2013)

Variety	Height (cm)			Number	
	Plants	Attachment of the lower bean	From the soil surface to the tip of the lower bean	Internodes	The branches
Ordinary method of sowing (inter-row spacing of 15 cm)					
Kharkivska shtambova	68.3	12.4	4.3	10.1	1.5
Nadiya	55.4	15.8	7.2	10.3	1.7
Bukovinka	57.6	15.3	6.6	11.7	1.4
Mavka	58.1	11.2	4.1	11.4	1.8
Podolyanochka	56.5	15.1	6.3	13.8	1.6
Ordinary method of sowing (inter-row spacing of 30 cm)					
Kharkivska shtambova	75.3	10.4	1.9	14.1	2.7
Nadiya	58.6	15.1	6.4	13.2	3.1
Bukovinka	64.1	14.2	4.7	16.4	2.4
Mavka	66.7	9.5	1.1	15.3	2.9
Podolyanochka	63.4	12.7	4.2	16.3	2.7
Wide-row method of sowing (inter-row spacing of 45 cm)					
Kharkivska shtambova	91.6	9.1	0.3	13.4	3.1
Nadiya	50.2	14.9	5.4	12.7	3.8
Bukovinka	53.8	15.6	6.7	11.3	3.0
Mavka	55.8	8.3	0.2	12.5	3.4
Podolyanochka	51.9	14.0	4.3	10.6	3.2

Therefore, it was established that the height of the plants depends on the variety and sowing methods. In case of Kharkivska shtambova variety, this figure amounted to 68.3-91.6 cm, Nadiya variety – 50.2-58.6 cm, Bukovinka variety– 53.8-64.1 cm, Mavka – 55.8-

66.7 cm, Podolyanochka variety is 51.9-63.4 cm. As we see, with the increase of row spacing, increasing the height of the plants.

As to the height of attachment of the lower bean and distance from the soil surface to the tip of the lower bean it is known that these figures describe the suitability for mechanized harvesting of beans. Our studies revealed that by the usual method of planting with wide row spacing of 15 cm height of attachment of the lower bean this figure was the highest in Nadiya variety and amounted to 15.8 cm; Mavka variety had the lowest – 11.2 cm. Decrease of this indicator was observed with the increase of the width of the rows. By the usual method of planting with wide row spacing of 30 cm height of attachment of the lower bean was the highest in Nadiya variety to 15.1 cm; Mavka variety had the lowest – 9.5 cm. In a wide-row method of planting with row spacing of 45 cm high, these values were in the variety Bukovinka – 15.6 cm, the variety Nadiya – 8.3 cm.



Figure 1. Form of bush of beans depending on the row spacing (the harvest-2013)

Observations indicate that the methods of sowing influenced the number of internodes and branches. By the usual method of planting with wide row spacing of 15 cm number of internodes was highest in grade Podolyanochka – 13.8 No, the lowest in the variety of Kharkovska shtambova – 10.1 No. Growth of this indicator was observed when increasing the width of the rows. By the usual method of planting with wide row spacing of 30 cm height of attachment of the lower bean was highest in Bukovynka variety – 16.4 No, Mavka variety had the lowest – 13.2 No. As a result of the wide-row method of planting with row

spacing of 45 cm high, these figures were for the variety of Kharkovska shtambova – 13.4 No, the lowest Podolyanochka variety – 10.3 No.

The number of branches depended on the method of sowing, at sowing in the usual way with wide row spacing of 15 cm and amounted to 1.4-1.8 No, by the usual method of planting with wide row spacing of 30 cm – 2.4-3.1 No, with wide-row method of planting with row spacing of 45 cm 3.0-3.8 No.

Analyzing the biometric characteristic of Podolyanochka variety we found that the sowing methods had an impact on the shape of the bush (fig. 1).

In the process of formation of organic matter it is accumulating in all parts of the plant, however, the maximum accumulation of dry matter does not always prove the effectiveness of the event. This criterion is the yield of the main products. Crop yield is the product of plant productivity and the total number of plants that remained at the time of harvesting.

The set of elements of plant productivity, referred to as the structure of the crop. The main features of the structure of the crop of beans are: the number of beans per plant, seed size, number of seeds from plants, their size (weight of 1000 seeds) and weight of seeds from plant (table 3).

Table 3

Plant productivity of beans depending on the varieties and sowing methods (Average from 2009-2013)

Variety	Quantity, (pieces)		Weight, (g)	
	beans from plant	seeds in the bean	seeds from plant	1000 seeds
Ordinary method of sowing (inter-row spacing of 15 cm)				
Kharkivska shtambova	24,3	3,9	94,9	201,67
Nadiya	19,0	5,0	96,1	238,27
Bukovinka	18,6	4,7	95,7	218,91
Mavka	22,9	4,9	108,5	222,34
Podolyanochka	22,3	4,4	98,6	224,08
Ordinary method of sowing (inter-row spacing of 30 cm)				
Kharkivska shtambova	28,6	3,4	97,6	285,51
Nadiya	21,9	4,6	101,1	225,51
Bukovinka	21,7	4,5	98,4	256,41
Mavka	25,1	5,0	124,3	207,93
Podolyanochka	24,5	4,5	110,6	213,58
Wide-row method of sowing (inter-row spacing of 45 cm)				
Kharkivska shtambova	36,2	2,9	104,5	298,71
Nadiya	23,5	4,5	106,3	228,34
Bukovinka	23,7	4,4	103,8	232,11
Mavka	28,3	5,2	147,2	215,09
Podolyanochka	29,4	4,7	138,3	259,67

Thus, the highest number of beans on the plant is set in Kharkivska shtambova – 24.3-36.2 No, the smallest in Nadiya variety – 19.0-23.5 No. Weight of seeds from plants partially depends on the previous value, but largely on the variety characteristics, and the highest was observed in Mavka variety – 108.5-to 147.2 g, the smallest in Kharkivska shtambova variety – 94.9-104.5 g.

Weight of 1000 seeds in the studied varieties depending on the sowing methods also changed. So when sown in the usual way with wide row spacing of 15 cm of Kharkivska shtambova variety, the value was 201.67 g, and the highest in Nadiya variety – 238.27 g. When sown in the usual way with wide row spacing of 30 cm the lowest weight of 1000 seeds was in Mavka variety – 207.93, and the highest in Kharkivska shtambova variety – 285.51. Sowing by wide-row method with row spacing of 45 cm ensured the growth of the weight of 1000 seeds. It was the highest for the variety of Kharkivska shtambova – 298.71 g, the lowest for the Mavka variety – 215.09 g.

The obtained data of harvest suggest that the value of the crop, depending on the variety and sowing methods also differed (table 4).

Table 4

The yield of seed beans depending on the variety and sowing methods, ($t \cdot ha^{-1}$) (average for the years 2009-2013)

Variety	The sowing methods				Average factor A	LSD factor A
	Ordinary (inter-row spacing of 15 cm)	Ordinary (inter-row spacing of 30 cm)	Wide-row (inter-row spacing of 45 cm)	Average factor A		
Kharkivska shtambova	1.66	1.58	1.64	1.63	0.06	
Nadiya	1.73	1.69	1.74	1.72		
Bukovinka	1.75	1.72	1.76	1.74		
Mavka	1.78	1.66	1.69	1.71		
Podolyanochka	1.76	1.71	1.75	1.74		
Average factor B	1.74	1.67	1.72	average experience – 1.71		
LSD factor B	0.04			LSD factor AB – 0.10; Sx – 2.01.		

The results of the research showed that the yield of seeds depends primarily on the varietal and the weather conditions of the growing season. In the years of research, the bean plants were sufficiently provided with heat and moisture. The highest yield of seeds of $1.78 t \cdot ha^{-1}$ was formed on the variant of Mavka variety when sown in the usual way with wide row spacing of 15 cm. The lowest yield of bean was obtained on the level $1.58 t \cdot ha^{-1}$ when sown by the usual way with wide row spacing of 30 cm of Kharkivska shtambova variety. By wide-row method of planting with row spacing of 45 cm higher yields were provided by a variety of Bukovynka – $1.76 t \cdot ha^{-1}$.

Conclusions

It was determined that the sowing methods had an impact on the duration of the interphase periods in case of beans varieties. In case of sowing with the usual way with wide row spacing of 15 cm, the length of the growing season was 75-85 days at the average. Sowing by the usual way with wide row spacing of 30 cm extended the vegetation period by 3-5 days, the wide-row method with wide row spacing of 45 cm extended the vegetation period by 4-10 days.

During the increase of the value of row spacing, the increase in individual productivity of bean plants and structure of yield was reported.

As a result, the yield depended on the variety and sowing methods. Sowing in the usual way with wide row spacing of 15 cm have provided the highest yield of Mavka variety on the level of 1.78 t·ha⁻¹, and the lowest in case of Kharkivska shtambova variety – of 1.66 t·ha⁻¹. In case of sowing in the usual way with wide row spacing of 30 cm the highest yield was for Bukovinka variety – 1.72 t·ha⁻¹, the lowest in Kharkivska shtambova variety is 1.58 t·ha⁻¹. In case of the wide-row planting method with wide row spacing of 45 cm, the biggest grain yield of bean was in the variants of Bukovynka variety – 1.76 t·ha⁻¹, the lowest in Kharkivska shtambova variety – 1.64 t·ha⁻¹.

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WPLYW CZYNNIKÓW TECHNOLOGICZNYCH NA WZROST, ROZWÓJ I PLON WYBRNAYCH ODMIAN FASOLI ZWYKŁEJ

Streszczenie. Niniejszy artykuł przedstawia wyniki badań dotyczących odmian fasoli zwykłej (*Phaseolus vulgaris L.*), wzrostu i rozwoju roślin w warunkach zachodniego lasostepu. Ponadto, określa czas trwania okresu wegetacyjnego, tworzenie się elementów składających się na wydajność roślinną, która dostarcza odpowiedniego poziomu plonu nasion w zależności od odmiany i metod siewu. Siew zwykły z szerokim 15-centymetrowym rozstawem dał najwyższy plon odmiany Mavka i był on na poziomie $1,78 \text{ t}\cdot\text{ha}^{-1}$. W wyniku siewu zwykłego z szerokim 30-centymetrowym rozstawem, odmiana Bukovynka osiągnęła najwyższy plon rzędu – $1,72 \text{ t}\cdot\text{ha}^{-1}$ a w wyniku siewu szerokiego z rozstawem wynoszącym 45 cm, plon wyniósł $1,76 \text{ t}\cdot\text{ha}^{-1}$.

Słowa kluczowe: fasola zwykła, odmiana, kwitnienie, dojrzałość, wydajność, plon