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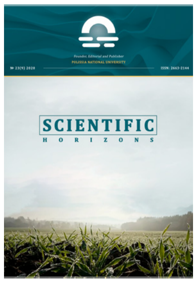

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Optimisation of the Vegetable Bean Production Process by Selecting Cultivars and Using Drip Irrigation

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Abstract. For the agricultural sector, there is a current trend of expanding the range of vegetables. Modern agricultural production is impossible without the cultivation of legumes – a cheap source of vegetable protein and one of the important links on which depends the balance of organic matter in the soil. The purpose of the study conducted in 2019-2020 was to investigate the cultivar specifics and the influence of drip irrigation on the growth and yield of vegetable beans and the development of a symbiotic system. The research involved field, laboratory, statistical, and calculation-analytical methods. Studies have indicated that the use of drip irrigation contributed to an earlier emergence of seedlings, a reduction in interphase periods, and earlier arrival of vegetable products by 4-7 days, depending on the cultivar. The weight of green beans increased by 35.9-41.9 g, depending on the cultivar. Yields of green beans increased by 3.5 t/ha (32.1%) in Karadag cultivar, 3.6 t/ha (31.3%) in Windsor cultivar, and 4.2 t/ha (39.2%) in Ukrainian Sloboda and Windsor cultivars. Among the experimental variants, the most productive cultivar on the dry-farming lands was the Ukrainian Sloboda, and on irrigated lands – Belarusian, Ukrainian Sloboda, and Windsor. The results indicate that the most developed nodulation apparatus was established in the Ukrainian Sloboda cultivar, where the largest mass was developed, but nodules on the plant were small (0.9 g on dry-farming lands and 1.3 g on irrigated lands). In general, drip irrigation contributed to the improved development of legume-rhizobial symbiosis of vegetable bean plants. The mass of the nodules on the drip irrigation increased by 0.3 g/plant regardless of the cultivar, and their amount increased by 1.5-9.0 pcs/plant. The presented results give an idea of legume agrocenosis functioning and the impact of irrigation on the main quality indicators of the product. Further research lies in the examination of the modes (rates, timing, multiplicity) of irrigation and their impact on the productivity of vegetable bean plants

Keywords: biochemical+ parameters, weight of green beans, nodulation apparatus, yield of green beans

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INTRODUCTION

One of the most important problems of Agriculture in Ukraine nowadays is the shortage of vegetable protein, equal to animal protein. Beans are an important source of biological nitrogen in agriculture, the importance of which has increased in the conditions of environmental degradation and lack of nitrogen fertilisers. The share of biological nitrogen in the nitrogen balance is very small and amounts to approximately 5%, and if appropriate conditions are created for the functioning of the legume-rhizobial system, it can increase up to 30%.

In the context of increasing the cost of anthropogenic resources and environmental tensions, alternative approaches to the development of agricultural technologies based on the concept of biologisation of agriculture and providing it with a resource-saving and sustainable development direction are required to ensure the sustainable functioning of the agroecosystems. Based on this, the selection of bean varieties and their cultivation with drip irrigation is an urgent problem of horticulture and agricultural production in general.

Beans are a genus of annual herbaceous plants in the legume family. Beans belong to the order Fabales (ordo *Fabales Nakai*), Legume family (*Fabaceae*), *Faba* Medik genus, which is represented by two types: Pliny beans (*F. Plinina* Trabut.) and horse beans (*F. Bona* Medik.) (syn. *Vicia faba* L., *Faba vulgaris* Moench., *Faba sativa* Bernh.). *Vicia faba* major, coarse-grained (the mass of 1000 grains reaches 2500 g), also called beans or vegetable beans, are used in horticulture [1; 2].

In the modern world, the nutritional relevance of bean seeds increases with a high nutritional value [3]. Among vegetable crops, these are the leaders in protein and amino acid content. Beans in technical ripeness are a valuable food product. In this phase, beans contain 6-15% of protein (up to 35% in mature seeds), 4.2% of carbohydrates, including 2.6% of sugars, as well as a large amount of mineral salts, mainly potassium, calcium, phosphorus, magnesium, sulphur, and ferrum. Green beans are rich in B vitamins, which play an important role in preventing aging and sclerosis. Grains contain 1% of fibre, 0.7% of ash, and 80% of water. In terms of calories, beans are 3.5 times more nutritional than potatoes and 6 times more nutritional than corn [4; 5].

The saturation of the crop rotation with beans helps to improve the structure of the soil and its mineral composition. After harvesting legumes per 1 ha, 20-70 centners of root and crop residues remain in the soil, which contain 45-130 kg of nitrogen, 10-20 kg of phosphorus, and 20-70 kg of potassium. Nitrogen-fixing nodules are formed on the roots, but not all formed nodules fix nitrogen from the air equally intensively. Bacteria that form small nodules, as a rule, fix little nitrogen or do not fix it at all [6]. When favourable conditions are created for legume-rhizobial symbiosis, legumes can fix an average of 120-140 kg/ha of nitrogen [7; 8].

Today, when growing vegetables, optimisation of the irrigation regime is of paramount importance. It determines the efficiency of the technology and the quality of the yield, total costs, the need for water and energy resources [9; 10]. The experience of advanced farms and data from research institutions show that good management practices and optimal irrigation regime contribute to the development of high and stable yields of vegetable crops [11-13]. It is widely acknowledged that irrigation costs and plant productivity vary depending on irrigation methods. Therefore, drip irrigation is promising in the cultivation of vegetable crops [14]. Drip irrigation is more efficient than other types of irrigation, both in terms of crop yield and water savings [15].

With proper agricultural technology, there is an increase in the yield of many crops: lettuce [16]; sugar beet [17; 18]; watermelon [19]; onions [20], and beans [21]. Beans are usually grown without irrigation, but in unstable climate conditions, drip irrigation becomes a necessity and can considerably improve the efficiency of cultivation technology [22-24].

The purpose of this study is the identification of cultivar features of the development of a high level of green beans yield under drip irrigation and the development of a nodulation apparatus of plants in the forest-steppe conditions of Ukraine. For the first time in the conditions of the forest-steppe of Ukraine, experimental data related to the development of a commercial crop of vegetable beans with drip irrigation were obtained.

MATERIALS AND METHODS

The studies on the technology of growing vegetable bean cultivars in the conditions of the Right-bank forest-steppe of Ukraine were conducted in 2019-2020 on the experimental field of the Department of horticulture of the Training Scientific and Production Department of the Uman National University of Horticulture according to a scheme that included eight options. The scheme of the two-factor experiment included the following cultivars of vegetable beans: Karadag st (standard), Ukrainian Sloboda, Belarusian and Windsor, which were grown without irrigation and with drip irrigation, maintaining soil moisture at the level of 80% to the technical ripeness of beans. The experiments were performed by the method of randomisation. The experiment is repeated four times. The area of the experimental section is 10 m^2. Beans were sown on April 5 in 2019 and April 10 in 2020, according to the 60×10 cm scheme.

The soil of the experimental section is podzolic heavy loamy black soil with a humus-accumulated horizon (humus content of about 1.5%) with a thickness of 40-45 cm; pH (salt) – 6.65. The ploughing layer contains 108.7 mg/kg of easily hydrolysed nitrogen (according to Kornfield); 59 mg/kg of labile phosphorus (according to Chirikov); 120.5 mg/kg of exchange potassium (according to Chirikov). The volume mass of the soil is 1.26-1.34 g/cm^3, the lowest field moisture capacity is 16.2% in the ploughing and 14.6% in the subsurface layers [25].

In the experiment, records and observations were made according to generally accepted methods:

1. The area of leaves was calculated by cutting, the amount of leaves, pcs/plants. in the phase of technical ripeness (harvesting) [26].

2. Yield accounting was carried out by the method of section weighing during the period of technical ripeness in accordance with the UNECE DSTU FFV-27:2007 [27].

3. The average weight of beans and green bean fruits was determined according to the generally accepted method [26].

4. The dry matter was identified by drying at t° 105°C according to DSTU 7804:2015 [28];

5. Protein content – by the Keldal method according to DSTU ISO 5983-2003 [29];

6. The amount and mass of rhizobia on plant roots were determined by the method of G.S. Posypanov [30].

Weather conditions (Fig. 1) during 2019-2020 differed in the main indicators, so the effectiveness of the study was evaluated objectively, and the data obtained are reliable.

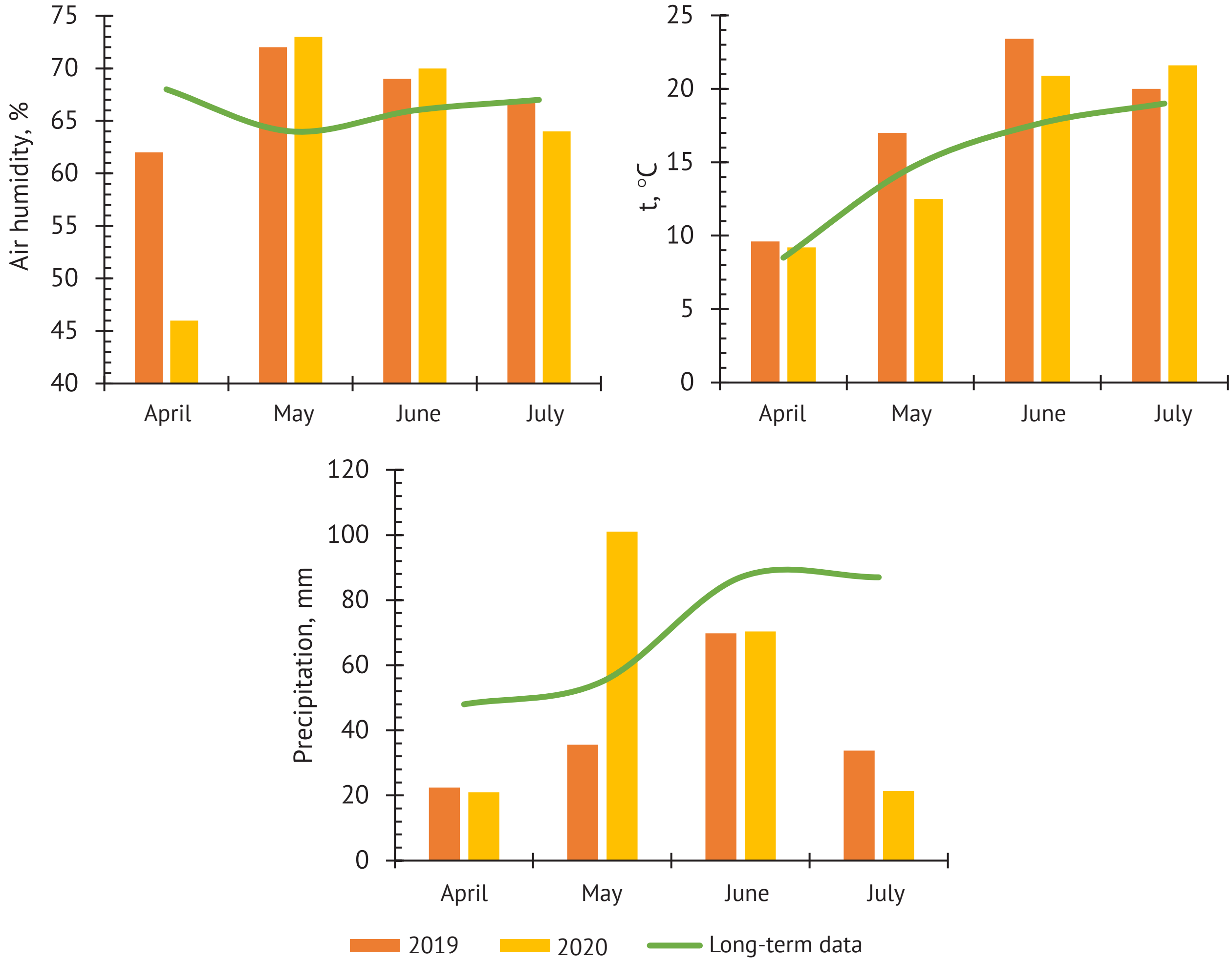

***Figure 1**. Key indicators of climatic conditions for the growing season of vegetable beans (2019-2020)*

RESULTS AND DISCUSSION

The studied cultivars of vegetable beans belong to the mid-ripening group. The conducted studies have identified that the processes of growth and development of bean cultivars during the growing season differed slightly depending on the cultivar and irrigation.

On average of two years, the duration of the period from sowing seeds to the emergence of seedlings ranged from 10-17 days. In cases with drip irrigation, the duration of this period was reduced by 4-5 days for Karadag, Ukrainian Sloboda and Belarusian cultivars; for Windsor cultivars, the specified period was reduced by seven days relative to the variant of dry-farming lands. The interphase period of bean development – bean filling was unchanged under irrigation and lasted 10 days for the Ukrainian Sloboda, Belarusian, and Windsor cultivars, and 11 days for the Karadag cultivar. From the filling of beans to period of technical ripeness, seven days passed in all experimental versions. Drip irrigation contributed to an earlier arrival of products, and therefore to the reduction in the growing season of plants by 4-7 days. The standard Karadag cultivar with drip irrigation reduced the growing season of plants by seven days, the Belarusian cultivar – by six days, the Ukrainian Sloboda cultivar – by five days, and the Windsor cultivar – by four days (Table 1).

***Table 1**. Duration of interphase growing seasons of vegetable beans depending on the cultivar and irrigation (2019-2020)*

Variant		Duration of interphase periods, days						
		Sowing – emergence of seedlings	Emergence of seedlings – budding	Budding – flowering	Flowering – pod formation	Pod formation – seed filling	Bean filling – technical ripeness	Growing season
Average for 2019-2020								
Dry-farming land*	Karadag st	16	27	30	15	11	7	105
	Ukrainian Sloboda	15	26	30	15	10	7	103
	Belarusian	16	27	30	15	10	7	102
	Windsor	17	25	31	13	10	7	97
Drip irrigation	Karadag st	11	22	27	15	11	7	98
	Ukrainian Sloboda	11	22	27	15	10	7	98
	Belarusian	11	21	27	14	10	7	96
	Windsor	10	20	29	14	10	7	93

***Note**: * – control, st – standard*

The results of biometric analysis established that growing vegetable beans on irrigation contributes to an increase in plant height by 4.7-12.2% relative to the variants on dry-farming land. Thus, on average of two years, plants of the Ukrainian Sloboda, Belarusian, and Windsor varieties cultivated on dry-farming lands were considerably higher compared to the control by 11.7, 10.0, and 12.8 cm (*$p \leq 0.05$ = 2.71 cm*). When cultivating beans with irrigation, the difference increased to 14.8, 13.0, and 19.2 cm, respectively.

On average of over two years, the amount of shoots on one plant cultivated with irrigation increased by 17.3-30.0%, or 0.7-1.0 pcs/plant with *$p \leq 0.05$=0.17 pcs/plant*. A considerable intervarietal difference was observed in Belarusian and Windsor cultivars on dry-farming land +0.4-1 pcs/plant, Belarusian and Windsor with irrigation systems +0.7-0.9 pcs/plant; in other cultivars, the increase in this indicator was inconsiderable.

On average by cultivars, the leaf area of vegetable bean crops increased by 21.2-24.9% over two years with drip irrigation. Ukrainian Sloboda and Belarusian cultivars formed a leaf area smaller than the control by 1.0 and 1.7 thous. m^2/ha on dry-farming land (*$p \leq 0.05$= 1.31 thous. m^2/ha*). On irrigation, the Ukrainian Sloboda and Belarusian cultivars were marked by a decrease in this indicator by 1.5 and 1.9 thous. m^2/ha. The Windsor cultivar formed a bigger leaf area of 0.3 and 1.0 thous. m^2/ha than control (Table 2).

Table 2. *Plant growth and formation of the leaf area of vegetable beans depending on the cultivar and drip irrigation*

Variant		Height of plants, cm	Amount of shoots, pcs./plant	Leaf area thous. m^2/ha
Dry-farming land*	Karadag st	63.5±2.12	3.1±0.14	27.3±1.47
	Ukrainian Sloboda	75.2±2.47	3.2±0.14	26.3±1.75
	Belarusian	73.5±2.12	3.5±0.00	25.6±1.98
	Windsor	76.3±2.33	4.0±0.07	27.5±1.48
Drip irrigation	Karadag st	66.5±2.12	3.8±0.21	33.4±1.55
	Ukrainian Sloboda	81.2±5.23	3.9±0.14	31.9±0.71
	Belarusian	79.5±6.36	4.5±0.07	31.4±0.64
	Windsor	85.6±4.66	4.7±0.35	34.4±1.70
Results of statistical processing				
HIP_{05}	*A*	*1.29*	*0.07*	*0.50*
	B	*1.92*	*0.10*	*0.79*
	AB	*2.71*	*0.17*	*1.31*
	CV, %	*10*	*15*	*12*

Note: ** – control, st – standard*

The amount of beans on average of two years increased on variants with drip irrigation by 47.8% for the Belarusian cultivar, by 50% for the Karadag and Ukrainian Sloboda cultivars, and by 62.5% for the Windsor cultivar relative to the variant without irrigation, which was considerable (*$p \leq 0.05$ = 0.50 pcs/plant*) (Table 3).

Table 3. *Morphometric parameters of vegetable beans depending on the cultivar and drip irrigation*

Variant		Amount of beans, pcs/plant	Amount of seeds, pcs/bean	Articulation height of the 1st bean, cm
Dry-farming land*	Karadag st	13.0±1.41	2.3±0.14	13.0±1.41
	Ukrainian Sloboda	12.0±0.00	2.4±0.21	14.6±0.49
	Belarusian	11.5±0.71	2.5±0.00	12.0±0.00
	Windsor	12.0±0.00	2.3±0.14	9.9±0.14
Drip irrigation	Karadag st	19.5±0.71	2.8±0.28	13.7±0.42
	Ukrainian Sloboda	18.0±0.00	3.0±0.00	14.8±0.35
	Belarusian	17.0±1.41	3.8±0.21	12.3±0.49
	Windsor	19.5±0.71	3.7±0.35	11.0±0.00
Results of statistical processing				
HIP_{05}	*A*	*0.22*	*0.06*	*0.13*
	B	*0.35*	*0.09*	*0.22*
	AB	*0.50*	*0.12*	*0.31*
	CV, %	*23*	*22*	*14*

Note: ** – control, st – standard*

Intervarietal difference was substantial in all variants. Thus, during dry-farming cultivation, the amount of beans in the Ukrainian Sloboda and Windsor cultivars was less by 1 pcs/plant regarding the standard. For the Belarusian cultivar, this indicator was less than the standard by 1.5 pcs. With drip irrigation conditions, the difference between the variants increased. Thus, in the Ukrainian Sloboda cultivar, a smaller amount of beans was noted relative to the standard by 1.5 pcs/plant, in Belarusian cultivar – a decrease against the Karadag standard cultivar by 2.5 pcs. (*p≤0.05=0.12 pcs.*), the Windsor cultivar formed the same amount of beans as the standard. Similar results were obtained by Ashenafi and Makaria [31], where a considerable difference in the number of beans on the plant was noted. According to this, Evol et al. [32] and Tafer et al. [33] indicated that the amount of beans on a plant primarily depends on the cultivar.

The possibility of mechanised harvesting depends on the articulation height of the first bean. Thus, when growing with irrigation, the articulation height of the first bean increased by 0.2-1.1 cm relative to variants without irrigation. This phenomenon mainly depended on an increase in the length of internodes. Considerably higher values of this indicator against the standard were characterised by the Ukrainian Sloboda cultivar, where the articulation height of the first bean was higher by 1.6 and 1.1 cm (*p≤0.05=0.31*) against the control cultivar on dry-farming land and drip irrigation. In the Belarusian and Windsor cultivars, this indicator was less than the control by 2.6-2.5 and 2.1-1.3 cm.

Drip irrigation contributed to a considerable increase in the mass of green beans on the plant by 35.9-41.9 g/plant with *p≤0.05=4.02* (Table 4). Thus, the Belarusian cultivar had a lower bean mass compared to the Karadag cultivar by 1.9 g/plant for cultivation on dry-farming land and higher mass by 4.1 g/plant with irrigation. In Ukrainian Sloboda cultivars, this indicator prevailed over the control by 1.6 and 7.2 g, respectively, according to cultivation methods. In the Windsor cultivar, the mass of green beans increased by 3.4 and 4.0 g/plant according to the variant. Crop yield is the most important indicator of the effectiveness of cultivation technology. With drip irrigation, the commercial yield indicator increased by 3.5-4.2 t/ha (*p≤0.05=0.46*), or 31.3-39.2%. Thus, the Ukrainian Sloboda cultivar had a higher yield than the control cultivar by 0.2 t/ha on dry-farming land and by 0.8 t/ha with irrigation. The Windsor cultivar had a yield higher than the control by 0.4 and 0.5 t/ha, according to the growing method. The Belarusian cultivar was characterised by a lower yield compared to the control by 0.2 t/ha on dry-farming land and a higher yield by 0.5 t/ha with irrigation (Table 4).

From the results above, it is evident that Karadag and Belarusian cultivars have a better response to improved growing conditions (drip irrigation). Protein content with drip irrigation increased by 12.8-16.5%, depending on the cultivar (Table 5).

***Table 4**. The mass of green beans and yield of vegetable beans depending on the cultivar and drip irrigation*

Variant		Mass of green beans, g/plant	± to C*	Yield of green beans, t/ha	± to st
Dry-farming land*	Karadag st	92.0±9.98	0	11.0±1.20	0
	Ukrainian Sloboda	93.6±9.13	1.6	11.2±1.10	0.2
	Belarusian	90.1±5.86	-1.9	10.8±0.70	-0.2
	Windsor	95.4±6.33	3.4	11.5±0.76	0.4
Drip irrigation	Karadag st	127.9±10.14	0	14.6±1.16	0
	Ukrainian Sloboda	135.1±11.56	7.2	15.4±1.32	0.8
	Belarusian	132.0±12.78	4.1	15.0±1.46	0.5
	Windsor	131.9±7.91	4.0	15.0±0.90	0.5
PResults of statistical processing					
HIP_{05}	*A*	*1.80*	–	*0.20*	–
	B	*2.85*	–	*0.33*	–
	AB	*4.02*	–	*0.46*	–
	CV, %	*19*	–	*16*	–

***Note**: * – control, st – standard*

Table 5. *Protein and dry matter content in green beans depending on the cultivar and drip irrigation*

Variant		Protein content, %	± to st	Dry matter content, %	± to st
Dry-farming land*	Karadag st	10.2±0.28	0	13.0±1.17	0
	Ukrainian Sloboda	10.9±0.14	0.7	13.3±1.13	0.3
	Belarusian	9.4±0.28	-0.8	12.6±0.70	-0.4
	Windsor	13.4±0.42	3.2	13.3±0.68	0.3
Drip irrigation	Karadag st	11.6±0.85	0	11.0±0.42	0
	Ukrainian Sloboda	12.3±0.71	0.7	11.5±0.42	0.5
	Belarusian	10.9±0.92	-0.6	11.3±0.42	0.3
	Windsor	15.5±2.12	3.9	11.7±0.35	0.7
Results of statistical processing					
HIP_{05}	*A*	*0.19*	–	*0.16*	–
	B	*0.30*	–	*0.25*	–
	AB	*0.42*	–	*0.36*	–
	CV, %	*16*	–	*8*	–

Note: ** – control, st – standard*

Thus, when cultivated on dry-farming land, the protein content of the Windsor cultivar was considerably higher relative to the standard (3.2% at *p≤0.05=0.42%*), in the Ukrainian Sloboda cultivar, the protein content increased by 0.7%, and in the Belarusian cultivar, the content was 0.8% less than in the Karadag cultivar. When cultivated with irrigation, the Windsor bean cultivar accumulated more protein than the Karadag cultivar by 3.9%, the Ukrainian Sloboda cultivar – by 0.7%, and the Belarusian cultivar – less than the control by 0.6%. Growing beans with drip irrigation contributed to a considerable reduction in the dry matter content by 1.3-2.0% (*p≤0.05=0.36*). The lower dry matter content relative to the Karadag cultivar was characterised by the Belarusian cultivar – 0.8 on dry-farming land and 0.3% higher with irrigation. The Ukrainian Sloboda cultivar had a higher dry matter content by 0.3 and 0.5% according to the growing method. The Windsor cultivar surpassed the Karadag cultivar by 0.3 and 0.7% according to the growing method.

The studies of the development of the nodulation apparatus have shown that the cultivation of beans *with irrigation* contributed to a considerable increase in the mass of nitrogen-fixing nodules (rhizobia) from 34.2% in the Ukrainian Sloboda cultivar to 114.9% in the Belarusian cultivar at the level of *p≤0.05=0.03 g/plant* (Fig. 2).

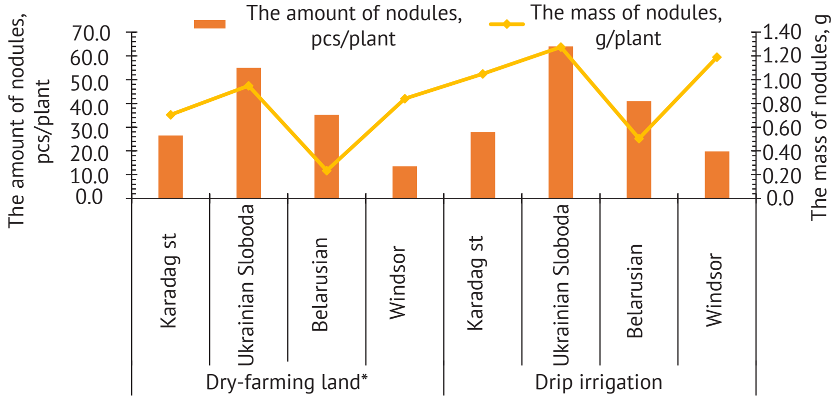

Figure 2. *The development of the nodulation apparatus of vegetable beans depending on cultivars and drip irrigation*

Results of statistical processing		*Amount of nodules*	*Mass of nodules*
HIP_{05}	*A*	*0.58*	*0.01*
	B	*0.93*	*0.02*
	AB	*1.31*	*0.03*

Note: ** – control, st – standard*

During the cultivation on *dry-farming land*, the standard Ukrainian Sloboda cultivar most considerably prevailed by weight of nodules (+34.8%), the difference was slightly lower for Windsor cultivar (+19.1%). The Belarusian cultivar formed lower masses of rhizobia by 66.7% compared to the Karadag cultivar. During the cultivation *with irrigation*, the same trend continued, but the difference between the variants decreased. Thus, Ukrainian Sloboda cultivar and Windsor cultivar formed rhizobia larger in weight by 21.4 and 13.3% relative to Karadag standard cultivar, the Belarusian cultivar had rhizobia 51.9% smaller in weight. Growing beans *with drip irrigation* contributed to a considerable increase in the number of rhizobia on the plant. Thus, Karadag cultivar increased their number relative to the variant without irrigation by 5.7%, Ukrainian Sloboda cultivar – by 16.4%, Belarusian cultivar – by 16.3%, and Windsor cultivar – by 46.7%. During the cultivation *on dry-farming land,* Ukrainian Sloboda and Belarusian cultivars formed by 28.5 and 8.7 pcs./plant more nodules relative to the Karadag cultivar, and the Windsor cultivar – less by 13.0%. During the cultivation *with irrigation*, Ukrainian Sloboda and Belarusian cultivars formed by 36.0 and 13.0 pcs./plant more nodules relative to the Karadag cultivar, and the Windsor cultivar – less by 8.2%. This means, the response of plants of Karadag cultivar was more positive to the growth of rhizobia, which helped to reduce the difference between the variants.

CONCLUSIONS

Thus, it can be stated that cultivating beans with drip irrigation improves the growth processes of plants, increases crop productivity, and improves soil conditions for the next crop by accumulating biological nitrogen in the ploughing soil layer. Cultivation of beans with drip irrigation contributed to an earlier arrival of products by 4-7 days, which in turn will be affecting the cost of production and profitability of production.

When cultivating beans with drip irrigation, the number of shoots on one plant increased by 17.3-30.0%, or 0.7-1.0 pcs/plant, the leaf area of plants increased by 21.2-24.9%, and the number of beans increased on variants with drip irrigation by 47.8% for the Belarusian cultivar, by 50% for the Karadag St and Ukrainian Sloboda cultivars, and by 62.5% for Windsor cultivar – relative to the variant with no irrigation.

Drip irrigation contributed to an increase in the mass of green beans on the plant by 35.9-41.9 g/plant, and the indicator of commercial yield increased by 3.5-4.2 t/ha, or 31.3-39.2%. The crude protein content with drip irrigation increased by 12.8-16.5%. Analysis of the data obtained indicates that drip irrigation contributes to an increase in the level of fulfilment of biological potential, which is especially high in Ukrainian Sloboda, Belarusian, and Windsor cultivars.

The cultivation of beans with drip irrigation contributed to a considerable increase in the number of nitrogen-fixing nodules on the plant by 34.2-114.9% and their mass by 5.7-46.7%, which, accordingly, increased the concentration of biological nitrogen in the soil. Cultivating beans with drip irrigation contributes to a substantial improvement in the formation of the legume-rhizobial system, which has a positive effect on the concentration of biological nitrogen in the soil.

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Оптимізація продукційного процесу бобу овочевого шляхом добору сортів і застосування краплинного зрошення

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Анотація. Для галузі землеробства актуальна тенденція розширення асортименту вирощування овочевих культур. Сучасне сільськогосподарське виробництво неможливе без вирощування бобових культур – дешевого джерела рослинного білка і однієї з важливих ланок, від якої залежить баланс органічної речовини в ґрунті. Метою досліджень, що проводилися у 2019–2020 рр., було вивчення сортових особливостей і вплив краплинного зрошення на ріст і урожайність бобу овочевого та формування симбіотичної системи. Для досліджень використовували польові, лабораторні, статистичні і розрахунково-аналітичні методи. Проведені дослідження дали змогу встановити, що застосування краплинного зрошення сприяло більш ранній появі сходів, скороченню міжфазних періодів і більш ранньому надходженню овочевої продукції на 4–7 діб залежно від сорту. Маса зелених бобів зростала на 35,9–41,9 г залежно від сорту. Урожайність зелених бобів збільшувалася на 3,5 т/га (32,1 %) у сорту Карадаг, 3,6 т/га (31,3 %) у сорту Віндзорські та 4,2 т/га (39,2 %) у сортів Українські слобідські і Віндзорські. Серед дослідних варіантів найбільш врожайним на богарі був сорт Українські слобідські, а на зрошенні – Білоруські, Українські слобідські та Віндзорські. Результати вказують, що найбільш розвинутий нодуляційний апарат формувався у сорту Українські слобідські, де формувалася найбільша маса, проте дрібних бульбочок на рослині (0,9 г на богарі та 1,3 г на зрошенні). Загалом краплинне зрошення сприяло покращеному розвитку бобово-ризобіального симбіозу рослин бобу овочевого. Маса бульбочок на краплинному зрошенні зростала на 0,3 г/росл. незалежно від сорту, а їх кількість – на 1,5–9,0 шт./росл. Представлені результати дають уявлення про функціонування бобового агроценозу та вплив зрошення на основні якісні показники продукту. Подальші дослідження полягають у вивченні режимів (норм, строків, кратності) зрошення та їх вплив на продуктивність рослин бобу овочевого

Ключові слова: біохімічні показники, маса зелених бобів, нодуляційний апарат, урожайність зелених бобів