

UDC 633.63:631.559:631.6(477.7)

DOI <https://doi.org/10.32782/2226-0099.2026.149.2.4>

YIELD OF SUGAR BEET ROOTS AS A FUNCTION OF AGRONOMIC FACTORS UNDER IRRIGATED CONDITIONS IN SOUTHERN UKRAINE

Mynkina H.O. – Candidate of Agricultural Sciences,
Associate Professor at the Department of Botany and Plant Protection,
Kherson State Agrarian and Economic
orcid.org/0000-0003-2240-9301

This article presents the results of research into the influence of agronomic factors on the yield of sugar beet roots under irrigation.

*Among the main agricultural crops grown in Ukraine, sugar beet (*Beta vulgaris*) occupies a significant place. This plant is an important source of lower-cost sugar due to its relatively short growing season and lower requirements for fertilisers and irrigation compared to sugar cane. The main root of the beet contains between 13 and 22% sugar. Increasing gross yields is crucial for meeting domestic demand for sugar and narrowing the gap between production and consumption in the country.*

The aim of this study is to provide a scientific basis and experimentally verify the effectiveness of agronomic practices for growing sugar beet under irrigation, taking into account the biological characteristics of the crop.

The objectives of the study were: to analyse the influence of agronomic factors on the growth, development and yield of sugar beet roots; to evaluate the effectiveness of applying agronomic practices; to develop recommendations for optimizing sugar beet cultivation technology to ensure stable productivity in the conditions of southern Ukraine.

Object of the study. The processes of growth, development and yield formation of sugar beet roots under the influence of various agronomic factors.

Subject of the study: The influence of cultivation techniques on the yield of sugar beet roots.

Research methods: field experiments – establishing experimental plots with sugar beet under various fertilization regimes, tillage methods, sowing dates and plant densities; laboratory analyses and statistical methods – mathematical processing of the research results.

The experiment is a four-factor design, including the following factors and treatments: Factor A – ploughing depth: 20–22 cm and 28–30 cm; Factor B – nutrient background: no fertilizer; $N_{150}P_{150}K_{60}$; manure 40 t/ha + $N_{150}P_{150}K_{60}$; manure 40 t/ha; Factor C – sowing dates: first date – when the soil temperature at the seed depth (4–5 cm) reaches 6–8°C; second date – ten days after the first; third date – twenty days after the first; Factor D – plant density: 90, 100 and 130 thousand plants/ha.

The results of the studies showed that the cultivation techniques investigated influenced the yield of sugar beet.

The application of mineral fertilisers $N_{150}P_{150}K_{60}$ contributed to an increase in root yield of 89.2–167.2%, organic-mineral fertilisers (40 tonnes/ha of manure + $N_{150}P_{150}K_{60}$) – by 102.2–197.0%, and purely organic fertilisers – by 31.7–82.6%, depending on ploughing depth, sowing date and plant density.

The highest yield of sugar beet roots – 855–869 c/ha – were obtained under different application regimes for organo-mineral fertilisers during the second sowing period and at a plant density of 110,000 per hectare for both ploughing depths. The application of mineral fertilisers ($N_{150}P_{150}K_{60}$) led to an increase in root crop yield of 89.2–167.2%, organic-mineral fertilisers – by 102.2–197.0%, and organic fertilisers alone at a rate of 40 t/ha of manure – by 31.7–82.6%, depending on ploughing depth, sowing date and plant density.

Key words: sugar beet, root crop yield, ploughing depth, nutrient background, sowing dates, plant density.



© Mynkina H.O., 2026

Стаття поширюється на умовах ліцензії CC BY 4.0

Минкіна Г.О. Урожайність коренеплодів буряку цукрового залежно від агротехнічних факторів за зрошення в умовах півдня України

В статті наведено результати досліджень з вивчення впливу агротехнічних факторів на урожайність коренеплодів буряку цукрового при зрошенні.

Серед основних аграрних культур, які вирощуються в Україні, значне місце належить буряку цукровому (*Beta vulgaris*). Ця рослина є важливим джерелом менш вартісного цукру завдяки відносно короткому періоду вегетації та меншим вимогам до добрив і зрошення порівняно з цукровою тростиною. У головному корені буряка міститься від 13 до 22% цукру. Збільшення валових зборів має вирішальне значення для задоволення внутрішнього попиту на цукор та скорочення розриву між виробництвом і споживанням у країні.

Метою роботи є наукове обґрунтування та експериментальна перевірка ефективності агротехнічних заходів вирощування буряку цукрового за зрошення з урахуванням біологічних особливостей культури.

Завданням дослідження було: проаналізувати вплив агротехнічних факторів на ріст, розвиток та урожайність коренеплодів буряку цукрового; оцінити ефективність застосування елементів агротехніки; розробити рекомендації щодо оптимізації технології вирощування буряку цукрового для забезпечення стабільності продуктивності в умовах півдня України.

Об'єкт дослідження. Процеси росту, розвитку та формування урожаю коренеплодів буряку цукрового за впливу різних агротехнічних факторів.

Предмет дослідження. Вплив елементів технології вирощування на формування урожаю коренеплодів буряку цукрового.

Методи дослідження: польові експерименти – закладання дослідних ділянок із різними системами удобрення, сортами за різних погодних умов року; лабораторні аналізи – визначення фенологічних та біометричних показників росту і розвитку сортів пшениці озимої; статистичні методи – математична обробка результатів досліджень; порівняльний аналіз – оцінка ефективності агротехнічних заходів за різних погодних умов року.

Дослід чотири факторний, включає такі фактори та варіанти: Фактор А – оранка на глибину 20-22 см та 28-30 см; Фактор В – фон живлення: без добрив, $N_{150}P_{150}K_{60}$, Гній 40 т/га + $N_{150}P_{150}K_{60}$, Гній 40 т/га; Фактор С – строки сівби: перший строк – при температурі ґрунту на глибині загортання насіння (4-5 см) – 6-8°C; другий – через десять, третій – через 20 днів після першого строку;

Фактор Д – густина стояння рослин: 90, 110 та 130 тис./га.

Результати досліджень показали, що елементи технології вирощування, які досліджувалися впливали на урожайність буряку цукрового.

Внесення мінеральних добрив $N_{150}P_{150}K_{60}$ сприяло збільшенню врожаю коренеплодів на 89,2-167,2%, органо-мінеральних 40 т/га гною + $N_{150}P_{150}K_{60}$ – на 102,2-197,0 і тільки органічних – на 31,7-82,6% залежно від глибини оранки, строку сівби й густоти стояння рослин.

Найбільший урожай коренеплодів буряків цукрових – 855-869 ц/га – отримано у варіантах внесення органо-мінеральних добрив за другого строку сівби й густоти стояння рослин на одному гектарі 110 тисяч при обох глибинах оранки. Внесення мінеральних добрив $N_{150}P_{150}K_{60}$ сприяло збільшенню врожаю коренеплодів на 89,2-167,2%, органо-мінеральних – на 102,2-197,0 і тільки органічних нормою 40 т/га гною – на 31,7-82,6% залежно від глибини оранки, строку сівби й густоти стояння рослин.

Ключові слова: буряк цукровий, урожайність коренеплодів, глибина оранки, фон живлення, строки сівби, густина стояння рослин.

Statement of the problem. The objectives of modern agriculture are the most productive use of all agricultural land to obtain high-yielding, high-quality and sustainable harvests, the creation of the necessary conditions for the systematic restoration and improvement of soil fertility, the rational use of natural and production resources, taking into account the optimisation of water and nutrient regimes, and the protection of the soil and the environment as a whole.

The cultivation of sugar beet in southern Ukraine is of strategic importance for meeting domestic sugar requirements. However, the regions climatic conditions, particularly erratic rainfall and high temperatures, necessitate the use of irrigation and the optimisation of agricultural practices.

Among the main agricultural crops grown in Ukraine, sugar beet (*Beta vulgaris*) occupies a significant place. This plant is an important source of lower-cost sugar due to its relatively short growing season and lower requirements for fertilisers and irrigation compared to sugar cane. The main root of the beet contains between 13 and 22% sugar. Increasing gross yields is crucial for meeting domestic demand for sugar and narrowing the gap between production and consumption in the country.

The cultivation of sugar beet and the production of sugar from the root crops are declining year on year. The needs of the national economy are not yet fully met by domestic sugar production.

In addressing this challenge, a significant role is played by studying the influence of agronomic factors on the yield of sugar beet roots under irrigation.

The quality of the roots is determined by a complex of factors, among which soil and climatic conditions and agronomic factors are of paramount importance. Also important are the fertilisation system, soil cultivation, plant protection against diseases, pests and weeds, the crop's position in the crop rotation, sowing dates, sowing density and varietal characteristics.

Therefore, scientific research aimed at studying the main agronomic practices for growing sugar beet under irrigation in southern Ukraine, and their impact on root yield, is highly relevant and of interest to agricultural production.

Analysis of recent studies and publications. Recent scientific works emphasise that it is precisely a comprehensive approach to soil cultivation, fertilisation, the selection of sowing dates and plant density that enables stable yields of high-quality sugar beet roots to be obtained [1].

Sugar beet root production in Ukraine remains insufficient. Studies show that the methods and depth of soil tillage do not have a significant impact on the yield of sugar beet roots. Thus, in the experiments by Buć O.V. and Filonenko S.V., yield was higher with ridge tillage compared to non-ridge tillage. On chestnut soils, these indicators were similar [2]. Mynkin M.V. noted the positive effect of surface and shallow tillage, explaining this by the acceleration of technical ripening and the redistribution of assimilates into the root crops [3].

Experiments on chernozems have shown that the highest yields and sugar content were achieved when 210 kg/ha of NPK was applied in combination with 30 t/ha of manure. Many authors confirm that the combination of organic and mineral fertilisers provides the greatest increase in yield. At the same time, excessive doses of mineral fertilisers are economically unviable: they reduce sugar content and do not provide a corresponding increase in yield [4].

Research by many authors [5,6] indicates that the application of mineral fertilisers in combination with organic ones provides the highest increase in yield and sugar yield. For instance, on podzolised chernozems, the application of 30 t/ha of manure together with $N_{140}P_{140}K_{140}$ increased yield by 5.1% and sugar yield by 0.6 t/ha compared to the treatment using mineral fertilisers alone. At the same time, excessive doses of mineral fertilisers are economically unviable, as they reduce sugar content and do not provide a corresponding increase in yield.

A number of studies [7] have shown that tillage methods and depth do not have a decisive influence on sugar content, but may affect the technical ripening of root crops. Surface and shallow tillage promotes the redistribution of assimilates into the root crops, which has a positive effect on their quality.

Sowing dates are an important factor: even a one-day delay from the optimal date reduces yield by 5–7 c/ha and sugar yield by 1–2 c/ha. If sowing is delayed by 5–6 days, yield falls by 21–71 c/ha, and sugar yield by 7–18 c/ha [8].

Plant density also has a direct impact on sugar beet yield. The highest yield was observed at a density of 96,000 plants per hectare, whereas excessive density (114,000 plants per hectare) reduced it [9,10].

In the southern regions of Ukraine, irrigation is the key factor in stabilizing sugar beet yields. It enables the potential of modern hybrids to be realized, compensates for moisture deficits and ensures a uniform supply of nutrients.

Thus, an analysis of recent studies confirms that the yield of sugar beet roots in the southern regions of Ukraine is determined by a complex of agronomic factors. The most significant of these are the tillage system, fertilization, sowing dates, plant density and the use of irrigation. It is the combination of these factors that enables stable yields and increases the efficiency of sugar production [11,12].

Problem statement. The formation of the productivity of any agricultural crop, influenced by many factors—including those under study—occurs systematically throughout the entire growing season. Research into the production processes of sugar beet was aimed at studying the influence of the factors under investigation on growth and development processes. An analysis of sugar beet root yield showed that this indicator depended on and varied under the influence of the factors under investigation.

The aim of this study is to provide a scientific basis for and experimentally verify the effectiveness of agronomic practices for the cultivation of sugar beet under irrigation, taking into account the biological characteristics of the crop.

The objectives of the study were to analyse the influence of agronomic factors on the growth, development and yield of sugar beet roots; to evaluate the effectiveness of applying agronomic practices; to develop recommendations for optimizing sugar beet cultivation technology to ensure stable productivity in the southern regions of Ukraine.

Object of the study. The processes of growth, development and yield formation of sugar beet roots under the influence of various agronomic factors.

Subject of the study. The influence of cultivation technology elements on the yield formation of sugar beet roots.

Research methods: field experiments – establishing experimental plots with sugar beet under various fertilization regimes, tillage methods, sowing dates and plant densities; laboratory analyses and statistical methods – mathematical processing of the research results.

The study was conducted on dark chestnut soil in the Ingles Irrigation System. The 0–30 cm soil layer contains 2.5–3.1% humus, 19–26 mg/kg of available nitrogen, 38–40 mg/kg of P_2O_5 and 350–500 mg/kg of K_2O .

The four-factor experiment includes the following factors and treatments:

Factor A – ploughing depth: 20–22 cm and 28–30 cm.

Factor B – nutrient background: no fertiliser; $N_{150}P_{150}K_{60}$; manure 40 t/ha + $N_{150}P_{150}K_{60}$; manure 40 t/ha.

Factor C – sowing dates: first date – when the soil temperature at the seed depth (4–5 cm) reaches 6–8°C; second date – ten days after the first; third date – twenty days after the first.

Factor D – plant density: 90, 100 and 130 thousand plants/ha.

Total plot area – 104 m², plot area – 60 m², experiment repeated four times. Total experimental field area – 4992 m². Variants arranged in a sequential design.

The agricultural practices for growing sugar beet in the experiment were standard for the region, with the exception of the factors under investigation. The preceding crop in the experiment was winter wheat. The crop residues were ploughed into the soil to enrich it with organic matter and biological nitrogen.

Research, plant monitoring and yield recording were carried out in accordance with research methodologies and regional guidelines [13; 14; 15].

Presentation of the main research material. In the southern Steppe of Ukraine, on dark chestnut soils under irrigation, studies were conducted to investigate the combined effect of ploughing depth, nutrient background, sowing date and plant density on sugar beet yield.

The yield of sugar beet roots depended on the factors under investigation and varied: in variants without fertilizer application – from 212 to 329 c/ha; with mineral fertilizer application – from 492 to 792; with organo-mineral fertilizer application – from 542 to 869; and with organic fertilizer application – from 357 to 540 c/ha (Table 1).

The lowest root crop yield was obtained in the treatments involving ploughing to a depth of 20–22 cm, without the application of fertilisers, in the third sowing date with plant density of up to 130,000 plants/ha (212 c/ha), whilst the maximum yield – 869 c/ha – was achieved with shallow ploughing, the application of organic-mineral fertilizers, and the second sowing date with plant density of up to 110,000 plants/ha.

Fertilizers contributed the most to yield formation, accounting for 82.95–84.41%. Sowing dates came second, with these figures ranging from 9.35 to 9.69, and in third place was the ‘plant density’ factor, which influenced yield by 2.74 to 4.03%. The ‘ploughing depth’ factor altered root crop yield by only 0.07–0.13%. There was also a low degree of interaction between factors, ranging from 0.01 to 1.65%.

Without the use of fertilizers, as well as when applying only mineral and only organic fertilizers, higher yields of sugar beet root crops were obtained in the deep ploughing variants, and in the variant involving the application of organo-mineral fertilizers – shallow ploughing to a depth of 20–22 cm and the intensity of flax fabric decomposition.

With shallow tillage, crop residues and fertilizers are mixed with a smaller volume of soil; in other words, when nutrient levels are already high, deep ploughing does not always lead to higher yields. With shallow tillage and the application of organo-mineral fertilisers, soil biological activity was certainly higher.

Changes in sugar beet yield were observed depending on the increase in ploughing depth from 20–22 to 28–30 cm. As can be seen, the greatest yield increase was observed in the treatments without fertilizer application (16–36 c/ha), with mineral fertilisers – 5–24 c/ha, and with organic fertilizers – 12–19 c/ha, depending on sowing dates and plant density, respectively. With the use of organo-mineral fertilisers, higher yield figures were recorded in the variants where ploughing was carried out to a depth of 20–22 cm – by 3–17 c/ha, depending on the sowing date and plant density of the sugar beet.

When applying mineral fertilizers at a rate of $N_{150}P_{150}K_{60}$ for sugar beet in the variants ploughed to a depth of 20–22 cm, yield increased by 257–462 c/ha, or by 109.0–167.2%, and when applying organo-mineral fertilizers – by 310–559 c/ha, or by 131.9–197.0%, and when using only organic fertilizers – by 109–219 c/ha, or by 42.9–82.6%, depending on the sowing dates and plant density.

In the variants with ploughing to a depth of 28–30 cm, the absolute increase in yield from fertilizer application was greater, but the relative (percentage) increase was lower compared to the variants with ploughing to a depth of 20–22 cm. This is explained by the fact that, without fertilizer application, the yield under 28–30 cm ploughing was already higher than under 20–22 cm ploughing.

In the ploughing variants to a depth of 28–30 cm, the increase in yield from the application of mineral fertilizers at a rate of $N_{150}P_{150}K_{60}$ amounted, depending on the sowing dates and plant density, to 242–463 c/ha, or 89.2–155.2%, against a background of organo-mineral fertilizers – 274–526 c/ha, or 102.2–175.8%, and against a background of organic fertilizers alone – 91–215 c/ha, or 31.7–76.5%, respectively.

Table 1

Yield of sugar beet roots depending on the factors studied, c/ha

Power background (Factor B)	Sowing period (Factor C)	Plant density, thousand/ha (Factor D)		
		90	110	130
Plowing to a depth of 20-22 cm (Factor A)				
No fertilizers	First	254	264	237
	Second	289	310	265
	Third	235	243	212
N ₁₅₀ P ₁₅₀ K ₆₀	First	532	619	572
	Second	633	772	708
	Third	492	615	565
Manure 40 tons/ha + N ₁₅₀ P ₁₅₀ K ₆₀	First	597	712	643
	Second	732	869	787
	Third	545	664	610
Manure 40 tons/ha	First	363	432	392
	Second	468	527	484
	Third	357	408	376
Plowing to a depth of 28-30 cm (Factor A)				
No fertilizers	First	287	288	253
	Second	324	329	281
	Third	268	277	248
N ₁₅₀ P ₁₅₀ K ₆₀	First	543	643	577
	Second	650	792	717
	Third	510	636	574
Manure 40 tons/ha + N ₁₅₀ P ₁₅₀ K ₆₀	First	582	695	637
	Second	725	855	775
	Third	542	650	594
Manure 40 tons/ha	First	378	449	405
	Second	480	540	496
	Third	374	427	392

Note: NIR05, c/ha, varied during the experimental years:

for ploughing depth from 5.96 to 9.61

for nutrient background from 8.43 to 13.59

for sowing date and plant density from 7.30 to 11.77

for interaction of factors from 35.78 to 57.64

Notes to the table:

Factor A – ploughing depth (20–22 cm; 28–30 cm).

Factor B – nutrient background (no fertilizer; N₁₅₀P₁₅₀K₆₀; manure 40 t/ha; manure 40 t/ha + N₁₅₀P₁₅₀K₆₀).

Factor C – sowing date (first, second, third).

Factor D – plant density (90; 100; 130 thousand plants/ha).

Unit of measurement for yield – centers per hectare (c/ha).

A significant increase in sugar beet root yield from the application of fertilizers was obtained during the second sowing period and at a plant density of 110,000 plants/ha.

An analysis of the effect of sowing dates on sugar beet yield shows that the highest yield was obtained during the second sowing period.

Increase or decrease in sugar beet root yield depending on plant density. Without the application of fertilisers, as the number of plants increased from 90 to 130 thousand/ha, the yield decreased by 17–43 c/ha depending on ploughing depth and sowing date; conversely, on fertilized plots, the yield increased by 16–75 c/ha, respectively.

Conclusions. Our research and records have shown that the cultivation techniques studied had an impact on sugar beet yield.

The application of mineral fertilisers $N_{150}P_{150}K_{60}$ contributed to an increase in root yield of 89.2–167.2%, organic-mineral fertilisers (40 t/ha of manure + $N_{150}P_{150}K_{60}$) – by 102.2–197.0%, and purely organic fertilisers – by 31.7–82.6%, depending on ploughing depth, sowing date and plant density.

The highest yield of sugar beet roots – 855–869 c/ha – was obtained in the variants involving the application of organic-mineral fertilisers during the second sowing period and a plant density of 110,000 per hectare at both ploughing depths. The application of mineral fertilisers $N_{150}P_{150}K_{60}$ contributed to an increase in root crop yield of 89.2–167.2%, organic-mineral fertilisers – by 102.2–197.0%, and organic manure alone at a rate of 40 t/ha – by 31.7–82.6%, depending on ploughing depth, sowing date and plant density.

Further research should focus on a comprehensive study of the interaction of sugar beet growth factors under current conditions of climate change and varietal characteristics, which will enable an increase in root crop yields under irrigation.

REFERENCES:

1. Енергетичний цукровий буряк. URL: <https://www.kws.com/ua/uk/produkty/tsukrovi-buryaky/energetychnytsukrovuj-buryak/>
2. Буць О.В., Філоненко С.В. Особливості технологій вирощування висадків цукрових буряків у виробничих підрозділах буряконасінницького господарства. «Наукові тенденції формування агротехнологій. Полтава. 2019. С21-27.
3. Минкін М.В. Вплив глибини основного обробітку ґрунту та фону живлення на урожайність буряку цукрового при зрошенні. ТНВ. Сільськогосподарські науки. Херсон, 2021. Вип. 122. С. 78-85
4. Глеваський В. Вплив доз добрив, густоти насадження рослин і сортових особливостей на продуктивність буряків цукрових. – Білоцерківський НАУ, 2023.
5. Стрілець О.П., Саблук В.Т., Доронін В.А. та ін. Вплив довготривалого внесення добрив на врожайність та енергетичну продуктивність буряків цукрових. – Інститут біоенергетичних культур і цукрових буряків НААН України, 2024.
6. Лихочвор В. В. Вплив добрив на врожайність цукрових буряків. Теорія і практика розвитку агропромислового комплексу та сільських територій: матеріали XVII Міжнар. наук.-практ. форуму. Львів, 2016. С. 6–9.
7. Минкін М.В., Минкіна Г.О. Вплив глибини оранки та фону живлення на біологічну активність ґрунту при вирощуванні буряку цукрового в умовах півдня України. *Таврійський науковий вісник. Сільськогосподарські науки. Херсон, 2024, DOI <https://doi.org/10.32782/2226-0099.2024.139.1.19> Вип. 139. С. 146-152*
8. Скорик В.В., Симоненко Н.В., Карнаух О.Б. та ін. Вплив попередників та систем основного обробітку ґрунту на урожайність буряку цукрового. – Уманський НУС, 2024.
9. Філоненко С.В., Шевельов О.П. Продуктивність цукрових буряків залежно від густоти стояння та строків збирання. – Дніпропетровський державний аграрний університет, 2004.
10. Mynkina H.O. Influence of agrotechnical factors on sugar content of sugar beet roots under irrigation. *Таврійський науковий вісник. Сільськогосподарські науки. Херсон, 2025, DOI <https://doi.org/10.32782/2226-0099.2025.142.2.3> Вип. 142. Том 2. С. 23-28*

11. Васильковська К.В., Юрченко К.В. Продуктивність цукрових буряків залежно від способів сівби в Степу України Матеріали 6 міжнародної науково-практичної конференції “Актуальні питання аграрної науки” Уманського НУС 2018, С46-48

12. Schlinker G. Stickstoffdüngung zu Zuckerrüben. Zuckerrübe. 2016. № 1. S. 45–48.

13. Дослідна справа в агрономії : навчальний посібник : у 2 кн. Кн. 1. / А.О. Рожков та ін.; за ред. А.О. Рожкова. Харків, 2016. 316 с.

14. Дослідна справа в агрономії: навчальний посібник: у 2 кн. Кн. 2. / А.О. Рожков та ін.; за ред. А.О. Рожкова. Харків, 2016. 342 с.

15. Ушкаренко В.О., Вожегова Р.А., Голобородько С.П., Коковіхін С.В. Методика польового дослідження: навчальний посібник. Херсон : Грінь Д.С., 2014. 448 с.

Дата першого надходження статті до видання: 02.04.2026

Дата прийняття статті до друку після рецензування: 22.05.2026

Дата публікації (оприлюднення) статті: 29.05.2026
