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Influence of feeding area on development, productivity and nutritional value of chicory

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Abstract. One of the main agrotechnical measures, which largely depends on the yield and quality of root chicory, is the correct placement of plants on the area. With different methods of sowing, placement schemes make it possible to ensure favorable conditions for plant growth and development and the maximum use of mechanization during the period of care for crops and harvesting. It was determined that the structure of the feeding area of the root chicory plant affects photosynthetic productivity. Therefore, the highest indicators of the net productivity of photosynthesis were distinguished by the placement of plants on the feeding area according to the scheme 45×22.5 cm and 22.5×45 cm, which had a positive effect on the yield of root crops and their content of inulin polysaccharide. The article presents the results of experimental studies that solve the scientific and practical problem of studying the elements of root chicory growing technology due to the optimization of the area of plant nutrition and the uniformity of their placement on productivity and quality indicators. It has been experimentally proven that with an increased rate of photosynthetic potential at a feeding area of 60×60 cm (with a plant density of 30,000 ha, the Umansky-97 variety was 9.2 $10^3 \times m^{-2}$ ha^{-1} per day, Umansky-99 - 9.3 $10^3 \times m^{-2}$ ha^{-1} per day with a decrease in the feeding area (45×45, 35×35, 45×22.5 cm), this indicator slightly increased, on average by variety, it was 10.1 to 10.8 $10^3 \times m^{-2}$ ha^{-1} per day. The highest indicator of inulin content in chicory root crops is the feeding area of 35×35 cm and was in the variety Umansky-97 - 18.5%, Umansky-99 - 18.7%, and the feeding area of 45×22.5 cm - 18.2% and 18.4%, respectively. Similarly, it was recorded that the feeding area of chicory plants significantly affects the yield of root crops. Thus, it was established that from a plant density of 60 to 120 $10^3 \times$ ha^{-1}, the productivity was on average 30 t ha^{-1} with an average weight of the root crop from 500 to 250 g, with an inulin content of 17.3 to 19.0%. According to the structure of the root crop, the productive part occupies on average from 82.7% to 91.6% of the total mass with inulin content from 17.3 to 19.0%.

Key words: root chicory, feeding area, variety, photosynthetic productivity, quality indicators.

INTRODUCTION

The soil and climatic conditions of the Right Bank Forest-Steppe of Ukraine differ significantly among themselves, which makes it necessary to sow root chicory at different times, because they are an important element of cultivation technology. Well-chosen sowing dates make it possible to obtain friendly seedlings, ensure the optimal onset of plant growth and development phases, uniform ripening of the crop and its suitability for long-term storage, while maintaining high quality indicators. A delay in sowing leads to a decrease in seed germination and a subsequent decrease in the yield. Also, the conducted studies established that the delay in sowing leads to the thinning of crops, unfriendly chicory seedlings due to the increase in soil temperature and loss of moisture at the depth of seed wrapping (Petrychenko et al., 2018; Tokarchuk et al., 2020; Honcharuk, et al., 2022).

The majority of scientists believe that the optimal conditions are when the seeds are placed at the depth of hard, dense soil with available moisture, while the top layer is loose, with good aeration. For this, it is important to correctly choose the calendar dates for sowing, taking into account the nature of the weather and climate conditions of the region, especially the spring period, the type of soil and the biological characteristics of the variety (Baranovsky & Potapenko, 2017; Ferrare et al., 2018; Hnatiuk et al., 2018; Reimer et al., 2020; Ebrahimi, et al., 2022).

Due to the warming observed in recent years, sowing too early in waterlogged, immature soil can usually lead to seed rot, disease damage and significant crop thinning. Scientists claim that the optimal time for sowing root chicory comes when the soil temperature at a depth of 2–3 cm 99 reaches 12–15 °C, and the soil is physically fertile. They also noted that the timing of sowing is related to the quality of soil preparation. High-quality soil cultivation is achieved with optimal humidity. When determining the timing of sowing, it is necessary to take into account not only the general soil and climatic conditions of the zone, but also the microclimate and topography of the field, the nature of the weather in spring, varietal characteristics and the method of preparing seeds for sowing. It is also important to note that in order to create the most favorable conditions for the appearance of friendly uniform chicory seedlings, their further development and the formation of a high yield, as well as the high-quality use of mechanization tools, the sowing of seeds should be carried out in the optimal agrotechnical terms, the optimal sowing rate and the depth of seed wrapping should be established (Barcaccia et al., 2016; Pouille et al., 2020; Mazur et al., 2021).

In the conditions of the Right Bank Forest-Steppe of Ukraine, one of the main conditions for increasing the yield and quality of marketable root chicory products is the use of purposeful elements of cultivation technology, one of them is the area of plant nutrition taking into account the varietal characteristics of the culture and natural and climatic resources. Taking into account the main elements of the root chicory growing technology, the presented research results are characterized by relevance. They consist in the scientific, theoretical and practical improvement of the study of the area of nutrition, which is based on the analysis of the laws of the formation of productivity, indicators of the quality of root crops and growing conditions.

MATERIALS AND METHODS

In the conditions of the Right Bank Forest-Steppe of Ukraine in recent years, not fully favorable weather and climatic conditions for the potential productivity of root chicory plants have been formed. The research region is characterized by a sufficient amount of effective air and soil temperatures, with an insufficient amount of precipitation per year, and their uneven distribution by growing season.

The soil cover at the experimental sites of the Khmelnytskyi DSGDS of the ICSHP of the National Academy of Sciences of Ukraine, where field experiments were conducted in 2017–2020, is represented mainly by podzolized chernozem of coarse silt-medium loam composition. The thickness of the humus horizon reaches 100–120 cm, while the humus content (according to Tyurin) is 2.2–2.8%. The soil is moderately supplied with nutrients - total nitrogen (according to Kjeldahl) - 0.157–0.169%, mobile forms of phosphorus and potassium (according to Chirikov) 16.5 and 11.5 mg per 100 g of soil, respectively.

Weather conditions during the research period were different. The average daily air temperature during the growing season was higher than the long-term average by 2.7 °C, and the amount of precipitation exceeded the long-term average by only 33.8 mm, or 6.8%. A significant deficit of precipitation, and thus of productive moisture in the soil, was noted in the critical periods of root chicory growth and development (July - 73.0%, August - 16.5% to the average multi-year value).

Agricultural technology in experimental studies is generally accepted for the cultivation zone.

Root chicory seeds were sown according to the scheme: - square 35×35 cm, 45×45 cm, 60×60 cm; rectangles 45×22.5 cm, 45×(27 + 18) cm, 45×(40 + 27) cm; rhombic - 22.5×45 cm. Varieties: Umansky-97; Umansky-99. Scheme of the experiment: two-factorial in three repetitions.

RESULTS AND DISCUSSION

The possibility of increasing the productivity of root chicory crops by optimizing the density of planting plants and the uniformity of their placement on the feeding area has not yet been fully studied. In addition, there is insufficient scientific information about the reaction of modern chicory varieties to changes in the feeding area, both in terms of the length of the rows and the width of the rows. In this regard, a study was conducted to study the geometric structure of the plant feeding area and the optical properties of chicory crops as the main factors and their influence on photosynthetic productivity (Tkach, 2020; Ivanyshyn, 2021; Bondarenko et al., 2022).

Various studies confirm that in most cases, depending on the variety of chicory and the place of its cultivation, the carbohydrate complex of chicory (inulides + sugars) can have quite high indicators, which are close to the indicators of sugar beets, which are rich in dry matter content. Even the analysis of the chemical composition of chicory seeds and seeds does not give a complete idea of its composition. 42% is ash, water, nitrogenous compounds, fats and carbohydrates, and 58% should be fiber and soluble carbohydrates. The fat content in chicory seeds is quite high - 17.78%, which should warn farmers about the conditions and terms of storage of chicory seeds, because it is known that seeds with a high fat content lose their germination faster than seeds with a low fat content.

When growing chicory as an industrial plant, the chemical composition of the root and leaves (as valuable waste) is of primary importance (Mazur et al., 2019). Therefore, it is necessary to study in detail the chemical and technical characteristics of root chicory and analyze, if possible, changes in its composition, depending on the requirements of the industry. Chicory processing is currently focused on the production of coffee drinks, powdered medicinal and prophylactic products, the production of inulin and medical supplements. In the production of coffee drinks, the industry makes demands for an increased content of inulin, as the main nutritional and taste substrate, an increased content of intibin glucoside, which gives a specific coffee taste and aroma, and a reduced protein content. The sugar industry studies such matters as the percentage of inulin and other soluble carbohydrates that easily turn into sugars, as well as a small amount of intibin, which can give the juice a bitter taste, as well as a reduced protein content, since it is proteins that contribute to the formation of thick molasses, and this makes it harder for the sugar to be released. The alcohol industry, like the sugar industry, is interested in a high content of soluble carbohydrates, as the main raw material for alcohol, in a high content of soluble proteins, which is a nutrient medium for the development of yeast cultures during sugar fermentation, as well as a high content of phosphorus and potassium salts, necessary for successful yeast reproduction (Dragan et al., 2004; Das et al., 2016; Mazur et al., 2020; Tkach, 2020; Pantsyreva, 2021; Puyu et al., 2021).

All other conditions being equal, variants with the same feeding area, but with a different geometric shape, were included in the experimental schemes, which were conventionally classified according to the following characteristics: rectangular with the placement of one, two and three plants from the center of symmetry of the feeding area: rhombic with the placement of one plant in the center opposite spaces free of plants in adjacent rows and a square with the placement of plants in dense crops on adjacent rows (Sabzevari et al., 2010; Zayova et al., 2016).

In this regard, a study was conducted to study the geometric structure of the plant feeding area and the optical properties of chicory crops as the main factors and their influence on photosynthetic productivity (Lyashuk et al., 2018; Didur et al., 2019; Bhunia et al., 2021).

The variants with the placement of plants on the area (rectangular 45×22.5 cm and rhombic 22.5×45 cm) were distinguished by the highest indicators of the net productivity of photosynthesis, which had a positive effect on the yield of chicory root crops and their content of inulin polysaccharide, which had a uniform placement of plants with an interval 20×25 cm along the row, and wrapping the seeds to a depth of 1–1.5 cm. Also, the options with the placement of plants according to the rectangular 45×22.5 cm and rhombic 22.5×45 cm schemes differed in terms of the net productivity of photosynthesis (Table 1).

The study of the influence of the rational placement of plants (with the shape of the feeding area close to a square) on the productivity of root chicory deserved special attention. Observations were made with the set of geometric structures of crops, which were created in the form of a square shape of the feeding area for one plant - 35×35 cm, 45×45 cm, 60×60 cm and rectangular - 45×22.5 cm, it was established that crops with a square shape of the feeding area 35×35 cm and a plant density of 80,600 ha^{-1} ensured a greater collection of root crops, which is 1.4 t ha^{-1} higher compared to the variant (45×22.5 cm with a plant density of 100,000 ha).

Table 1. The influence of plant density, the size and shape of the feeding area on the photosynthetic potential (FP, $10^3\times$ m^{-2} days ha^{-1}) and the net productivity of photosynthesis (NPF, g m^{-2} leaf per day) (average for 2017–2020)

Indicator	The shape of the feeding area, cm^2 (Factor A)							
	60×60		45×45(c)*		35×35		45×22.5	
Plant density, $10^3\times$ ha^{-1}	30		50		80		100	
Feeding area, cm^2	3,600		2,025		1,225		1,012.5	
Seed variety (Factor B)	Umansky-97	Umansky-99	Umansky-97	Umansky-99	Umansky-97	Umansky-99	Umansky-97	Umansky-99
Accounting days	NPF, g m^{-2} leaf per day							
10.07	3.5	3.7	3.7	3.9	3.9	4.2	3.5	3.6
26.07	7.8	8.1	7.3	7.5	7.1	7.3	5.8	6.0
28.08	6.7	7.0	5.7	5.9	6.0	6.2	3.7	3.9
30.09	5.3	5.5	3.8	3.9	3.3	3.4	2.9	3.1
Accounting days	FP, $10^3\times$ m^{-2} days ha^{-1}							
10.07	0.6	0.7	1.0	1.1	1.3	1.5	1.2	1.4
26.07	2.7	2.9	3.1	3.3	3.5	3.7	3.2	3.5
28.08	5.8	6.0	6.8	7.1	7.6	7.7	7.4	7.5
30.09	9.2	9.3	9.8	10.1	10.6	10.8	10.2	10.4

Note: (c)* – control.

Thus, with an increase in the indicators of the net productivity of photosynthesis, it was noted in chicory plants 26.07 with a feeding area of 60×60 (plant density 30 $10^3\times$ ha^{-1}) in the Umansky-97 variety - 7.8 g m^{-2} leaf per day, Umansky-99 - 8.1 g m^{-2} leaf per day, in the future, the NPF indicator decreased.

However, the photosynthetic potential (FP) increased with the growth and development of plants, which was affected by the feeding area. Thus, with a feeding area of 60×60 (with a plant density of 30 $10^3\times$ ha^{-1}), the FP indicator for the period of 30.09 was 9.2 in the Umansky-97 variety, and 9.3 $10^3\times$ m^{-2} ha^{-1} in the Umansky-99 variety. With a decrease in the feeding area (45×45, 35×35, 45×22.5 cm) with a plant density of 50, 80 and 100 $10^3\times$ ha^{-1}, the FP indicator increases and on average by varieties was 10.1 to 10.8 $10^3\times$ m^{-2} ha^{-1} per day.

The analysis of the complex effect of the investigated factors showed that crops with a square shape of the feeding area (35×35 cm) and a plant density of 80 $10^3\times$ ha^{-1} ensured the collection of inulin by 6.1 t ha^{-1}, which is 0.9 t ha^{-1} more, compared to the area nutrition (45×22.5 cm with a plant density of 100 $10^3\times$ ha^{-1}) (Table 2).

In terms of yield of root crops, on average, during the years of research, the feeding area of 35×35 cm variety Umansky-97 was - 31.1 t ha^{-1}, Umansky-99 - 32.4 t ha^{-1}. With reduced yield indicators, the feeding area of 60×60 cm stands out, the Umansky-97 variety - 24.0 t ha^{-1}, Umansky-99 - 24.1 t ha^{-1}. An intermediate place is occupied by the feeding area of 45×45 cm (c) - 30.1 to 30.3 t ha^{-1} and 35×35 cm - 31.1 to 32.4 t ha^{-1}, respectively.

Table 2. Productivity of root chicory varieties depending on the shape of the plant nutrition area (average for 2017–2020)

Indicator	The shape of the feeding area, cm (Factor A)							
	square						rectangular	
	60×60		45×45(c)*		35×35		45×22.5	
	Seed variety (Factor B)							
	Umansky-97	Umansky-99	Umansky-97	Umansky-99	Umansky-97	Umansky-99	Umansky-97	Umansky-99
Yield of root crops, t ha^{-1}	24.0	24.1	30.1	30.3	31.1	32.4	27.5	28.7
Inulin content, %	16.7	16.8	17.7	17.9	18.5	18.7	18.2	18.4
Collection of inulin, t ha^{-1}	3.3	3.4	5.3	5.4	5.9	6.1	5.1	5.2

Note: (c)* – control.

The content of inulin in root crops also depended on the feeding area. With the highest indicator, the feeding area of 35×35 cm stands out and was 18.5% in the Umansky variety-97, 18.7% in the Umansky-99 variety, 18.2% and 18.4% in the 45×22.5 cm feeding area, in accordance. The intermediate place is occupied by the feeding area of 45×45 cm (c) with indicators of 17.7% and 17.9%, corresponding to the variety. With reduced indicators, the feeding area of 60×60 cm stands out and was 16.7% of the Umansky-97 variety - 16.8% of the Umansky-99 variety - 16.8%.

Also, experimental studies have established that for the formation of high productivity of root chicory crops, the uniformity of the distribution of plants on the area is of great importance and affects the development and average mass of the root crop (Table 3).

Table 3. The relationship between the density of root chicory plants Umansky-99 by qualitative characteristics (average for 2017–2020)

Indicator	Plant density, $10^3 \times ha^{-1}$			
	60	80	100	120
The average mass of the root crop, g	500	375	300	250
Daily weight gain of the root crop, g	4.16	3.12	2.5	2.08
Inulin content, %	17.3	18.1	18.7	19.0
Collection of inulin, t ha^{-1}	5.19	5.43	5.64	5.7
Amount of dissolved ash, %	0.362	0.271	0.217	0.181
The ratio of the total mass of the root crop, % to the mass:				
head	12.3	9.5	7.1	5.1
productive part	82.7	84.2	87.2	91.6
actually the root	5.0	6.3	5.7	3.3

However, the larger the feeding area, the more significant the decrease in yield was observed. From the plant density of 60 and 120 $10^3 \times ha^{-1}$, the yield of root crops was 30.0 t ha^{-1}, the average weight of the root crop was 500 and 250 g, respectively; inulin content - 17.3 to 19.0%; inulin output - 5.19 and 5.7 t ha^{-1}. At the same time, root crops weighing more than 500 g made up almost 55% of the total mass of the crop in sparse sowing, and 13% in thickened sowing. At the same time, the experimental variety Umansky-99 was used.

It was established that an important indicator in the accumulation of quality indicators in chicory root crops is the productive part, which occupies an average of 82.7% (of the total mass) to 91.6%, regardless of plant density with a plant density of 60.000 ha^{-1} 12.3%, and the density of 120 $10^3\times$ ha^{-1} - 5.1%. A similar pattern is observed in the part of the root - the root itself, from 5.0 to 3.3%. From the total weight of the root crop, the head occupies a larger percentage in thinned sowing. This indicates that the content of inulin in root crops largely depends on the productive part of the root crop and on average at different densities was from 17.3% to 19.0%, with a harvest of 5.19 t ha^{-1} to 5.7 t ha^{-1}.

The analysis of the complex action of the studied factors showed that the average mass of root crops (Rk, g) depends on the density of plants (Sr, $10^3\times$ ha^{-1}) (Fig. 1). On average, over the years of research with an increased average mass of root crops, the density of plants was 60–80 $10^3\times$ plants per 1 ha, depending on the variety, was from 385 to 500 g. From a plant density of 120 $10^3\times$ ha^{-1}, the indicators of the average mass of root crops were from 235 g^{-1} to 250 g^{-1}, respectively varieties.

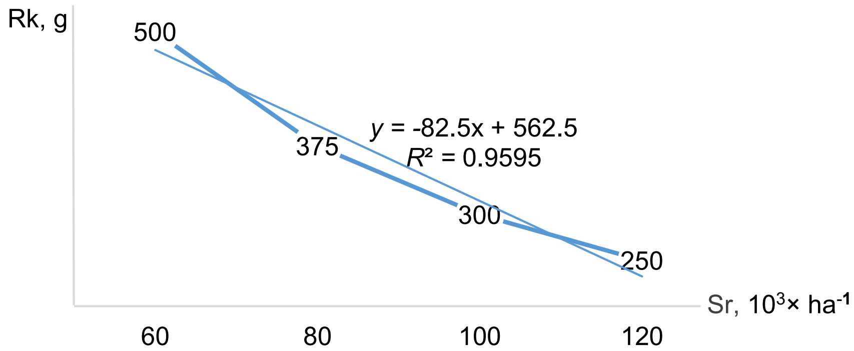

Figure 1. Dependence of the average root weight of root chicory (Rk, g) on plant density Sr, $10^3\times$ ha^{-1} (Average for 2017–2020).

The established analytical dependence between the density of chicory plants in the range of 60–120 10^3 ha^{-1}, and their qualitative indicators made it possible to realize the biological potential of plants in relation to the accumulation of root mass on the basis of a complex methodical approach. According to the assessment of the quality of chicory root crops, the content of inulin differed depending on the density of the plants (Fig. 2).

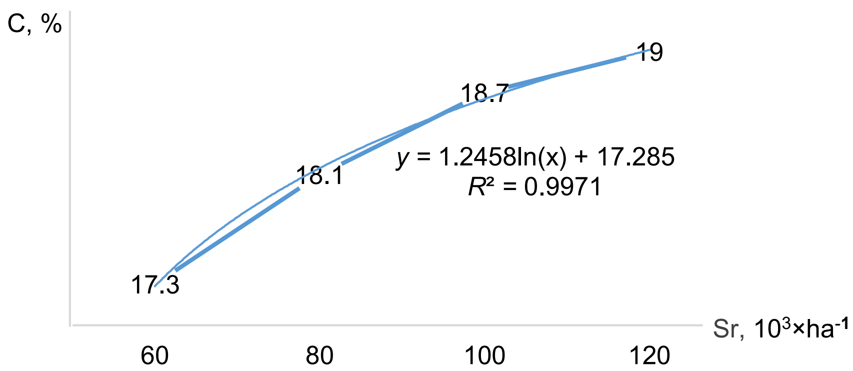

Figure 2. Dependence of the content of inulin in chicory roots (C, %) on the density of plants Sr, $10^3\times$ ha^{-1} (Average for 2017–2020).

The highest rate of inulin content was noted in root crops at a density of 120,000 plants ha^{-1} and averaged from 18.95 to 19.0%. The density of plants in general influenced and depended on the accumulation and collection of inulin from 1 ha (Fig. 3).

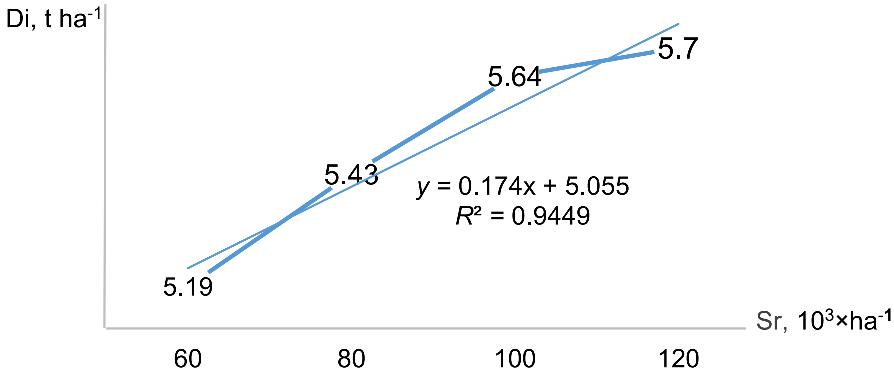

Figure 3. Dependence of inulin accumulation in root crops of root chicory (Di, t ha^{-1}) on plant density Sr, $10^3 \times$ ha^{-1} (Average for 2017–2020).

Thus, the dependence of inulin collection in root crops with plant density from 60,000 ha^{-1} of plants to 120,000 ha^{-1} of plants from 5.12 t ha^{-1} to 5.75 t ha^{-1} was established, which confirms the dependence of this indicator on plant density.

According to the results of mathematical calculations, the dependence of the quality indicators of root chicory is shown in Table 4.

Table 4. Mathematical models of the dependence of quality characteristics of root chicory on the density of plants, Sr, $10^3 \times$ ha^{-1} (average for 2017–2020)

Indicator	Regression equation	Multiple correlation coefficient, g	Coefficient of determination, R^2
Rk, g	$y = -82.5x + 562.5$	0.95	0.96
Dr, g	$y = -0.686x + 4.68$	0.98	0.96
C,%	$y = 1.2458\ln(x) + 17.285$	0.96	0.99
D_i, t ha^{-1}	$y = 0.174x + 5.055$	0.97	0.94
D_a, %	$y = -0.131\ln(x) + 0.3618$	0.98	0.99

Note Rk, g – mass of the root crop; D_r – daily increase in the mass of the root crop during the growing season, g; C – inulin content in root crops, %; D_i – collection of inulin polysaccharide from one hectare, t ha^{-1}; D_a – dissolved ash, %.

As the calculations show, between the quality indicators of root chicory and the density of plants - agrocenosis in the range of 60–120 $10^3 \times$ha^{-1} with an almost constant yield of root crops of 30.0 t ha^{-1}, namely: the mass of the root crop; daily weight gain of the root crop during the growing season; there is an analytical dependence, which was determined by the equation of a linear function of the form:

$\bar{y} = a \times b^x$;

Between the content of inulin – C, %; output of dissolved ash – D_a, % – by the equation of a logarithmic curve of the form:

$\bar{y} = b \times \log x - a$;

Indicators of the feeding area of the experimental plot of root chicory according to the distribution of the distance between root crops, the size, shape and aspect ratio of the feeding area, as well as the distribution of root crops in relation to size and weight and their significance in the formation of the crop according to the initial parameters before harvesting at a plant density of 90 $10^3\times$ ha^{-1}, root crops yield of 32 t ha^{-1} and vegetative mass of 19 t ha^{-1} of the Umansky-99 variety are shown in Table 5.

Table 5. Indicators of the feeding area and intervals between chicory roots of the Umansky-99 variety before harvesting (average for 2017–2020)

Indicator	Intervals between root crops, cm			
	0–15	15–30	30–45	45–60
Power area, $\frac{\text{см}^2}{\%}$	$\frac{337.5}{24.3}$	$\frac{1,012.5}{47.6}$	$\frac{1,687.5}{20.9}$	$\frac{2,362.5}{7.2}$
The shape of the feeding area, cm×cm	7.5×45	22.5×45	37.5×45	52.5×45
Aspect ratio of the feeding area, $K = \frac{L_p}{M}$	0.17	0.5	0.83	1.17

Note: L_p – distance between root crops in a row; M – row width 45 cm.

As a result of the research, it was established that the feeding area of root chicory plants, which was determined by the sowing structure under the existing cultivation technology with a row width of 45 cm at a plant density of almost 90 $10^3\times$ha^{-1} (close to the optimum) varies within large limits (V = 64.5%), and the number of plants with placement at close intervals in a row (0–15 cm) and a feeding area of 337.5 cm reached 24.3%. This led to a decrease in the degree of illumination of the leaf apparatus (shading) of adjacent plants, as well as to a decrease in the net photosynthetic productivity (NPF). On the contrary, when placing plants at intervals of 40 cm with a feeding area of almost 2,000 cm, the net potential of photosynthesis increased. However, only 7.2% of plants were placed on such intervals. An increase in the feeding area, as a rule, is associated with a decrease in the density of plants, and therefore there was a decrease in the overall productivity of root chicory per unit area.

Thus, the optimal feeding area of root chicory plants, which is close to a square, should be formed by the structure of sowing, taking into account its biological features, both by choosing a rational width between rows, and by evenly placing plants in rows with intervals of not less than 25 and not more than 35 cm with the aspect ratio of the feeding area corresponding to the rectangle K = 0.8–1.2.

The size and shape of the feeding area have a significant influence on the size and mass of root crops and, therefore, on the formation of the mass of the harvest of the Umansky-99 variety (Table 6). If the number of root crops with a diameter of 10–20 mm corresponded to a percentage value of 9% of their total collection, then their significance in the formation of the mass of the crop was only 2.1%, while with 7% of root crops with a diameter of 80–100 mm, the significance of their mass was 16.7% of the harvest or 9.1 t ha^{-1}, i.e. eight times more than the mass of root crops of the 10–20 mm fraction.

Table 6. Distribution of quality indicators of the Umansky-99 variety depending on the diameter of the root crop (average for 2017–2020)

Indicator	Root diameter, mm				
	10–20	20–40	40–60	60–80	80–100
Number of root crops, %	19	41	26	11	3
Significance in the formation of crop mass, %	12.1	15.2	34.5	27.5	10.7
Root mass Mr, g^{-1}	77.9	164.4	274.2	384.3	575.7
The ratio of leaf weight to root weight, D_r / D_a	1.68	1.57	1.14	0.82	0.69

For high-quality cutting of the gorse, the root crops were smaller (d_k = 10–20 mm), and were placed in a row at a distance of up to 10 cm and lay below the level of the soil surface. Therefore, when stored in the kagata (burta), root crops with a gichka or with a high cut are damaged and poorly stored.

CONCLUSION

The structure of the feeding area of root chicory plants affects photosynthetic productivity. Placement of plants on the feeding area according to the 45×22.5 cm and 22.5×45 cm scheme was distinguished by the highest indicators of net productivity of photosynthesis, which had a positive effect on the yield of root crops and their content of inulin polysaccharide.

With an increased rate of photosynthetic potential, it was noted at a feeding area of 60×60 cm (with a plant density of 30 10^3× ha^{-1} of the Umansky 97 variety was - 9.2 10^3× $10^3 m^{-2}$ ha^{-1} per day, Umansky-99 - 9.3 10^3× m^{-2} ha^{-1} per day with with a decrease in the feeding area (45×45, 35×35, 45×22.5 cm^{-1}), this indicator slightly increased, on average by variety, it was 10.1 to 10.8 10^3× m^{-2} ha^{-1} per day. The highest indicator of inulin content in chicory root crops is the feeding area of 35×35 cm and was in the variety Umansky-97 - 18.5%, Umansky-99 - 18.7%, and the feeding area of 45×22.5 cm - 18.2% and 18.4%, respectively.

The feeding area of chicory plants significantly affects the yield of root crops. From a plant density of 60,000 to 120,000 ha^{-1}, the yield averaged 30 t ha^{-1} with an average root weight of 500 to 250 g, with an inulin content of 17.3 to 19.0%.

According to the structure of the root crop, the productive part occupies on average from 82.7% to 91.6% of the total mass with inulin content from 17.3 to 19.0%.

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