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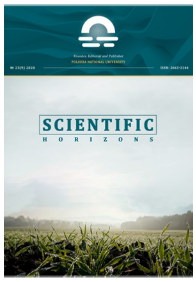

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Amaranth yield depending on the sowing rate

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Abstract. The main value of amaranth lies in its ability to accumulate a large amount of protein in its seeds and leaves. With a seed protein content of 15-18%, amaranth surpasses wheat (12-14%), rice (7-10%), maize (9-10%), and other grain crops. The purpose of this study was to establish the optimal seed sowing rates for amaranth under the conditions of the Western Ukrainian Forest-Steppe zone. The study employed general scientific methods such as analysis, synthesis, experimentation, description, observation, and comparison, as well as field methods like phenological observations and record-keeping, along with statistical and correlation-regression analyses for data

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processing. The sowing rates of the variety Kharkivskyi 1 were investigated under conditions of sufficient moisture on dark-grey forest soil. It was found that the field germination varied with different sowing rates. At a sowing rate of 0.2 million seeds/ha, the field uniformity was 70%, but it decreased to 60% at a sowing rate of 1.2 million seeds/ha, representing a 10% decrease. Higher sowing rates resulted in greater plant density. In the seedling stage, there were 14 plants per 0.2 million seeds/ha sowing rate, while at 1.2 million seeds/ha, the number of plants increased to 72/m². Plant survival during the vegetation period sharply decreased with increased planting density, from 86% at a sowing rate of 0.2 million seeds/ha to 45% at a sowing rate of 1.2 million seeds/ha. Therefore, before harvesting, the plant density was adjusted to 12-32 plants/m². The best combination of the main elements of the structure was found to be 21 plants/m² and 26 plants/m², with a grain weight per plant of 20.4g and 16.1g, respectively. The highest grain yield of amaranth variety Kharkivskyi 1 was obtained at sowing rates of 0.4 million seeds/ha and 0.6 million seeds/ha, resulting in 4.28 t/ha and 4.20 t/ha, respectively. Any increase or decrease in sowing rates led to a decrease in the yield level. The results of this study can be used for further establishment and improvement of the main elements of amaranth cultivation technology by both scientific institutions and agricultural farms

Keywords: amaranth; sowing rate; crop structure; productivity

INTRODUCTION

Amaranth is a fast-growing multipurpose crop that thrives on poor soils and exhibits high resilience to extreme stress conditions. Its grain is considered a potentially valuable supplementary food crop, as it provides significant amounts of micro and macro nutrients as a single crop, unlike many staple food crops in the world. Amaranth is particularly rich in lysine compared to other cereals and pseudo-cereals. Another noteworthy characteristic is its adaptability to various environments, making it a competitive crop suitable for cultivation worldwide (Weerasekara, 2020). In the African continent, amaranth is among the most widely cultivated and consumed local crops (Olaniyi, 2022). The increasing global population, especially in arid and semi-arid regions facing food and land shortages, necessitates the use of lands unsuitable for traditional agriculture due to soil salinity. Soil salinity is a significant issue affecting approximately 24% of Africa. To address this problem, cultivating salt-tolerant, high-yielding amaranth genotypes proves to be a solution (Doza *et al.*, 2019). Currently, amaranth is grown in many countries across the Americas, Southeast Asia, and Africa. However, in Europe, its cultivation potential and utilization remain underestimated (Różewicz, 2021).

Amaranth belongs to the crops characterized by limited cultivation technologies. For the normal growth and development of amaranth plants, they require an adequate area of nutrition, providing sufficient nutrients and water for the formation of necessary vegetative mass and grain. Therefore, the formation of high-yielding amaranth crops largely depends on the optimal sowing rate, which is determined by climatic conditions, soil fertility, fertilization system, biological characteristics of the variety, sowing dates, methods, seed quality, and other factors. Yield decreases both in sparse and dense plant placements on the field. Agrophytocenoses are known for their ability to self-regulate and are sensitive to excessive crop density, which leads to significant reduction of already formed morphological elements: premature drying and wilting of lower layers of leaves, decrease in stem and leaf mass, reproductive organs, and overall plant biomass, resulting in reduced grain yield (Dudka, 2019).

The grain yield level of amaranth largely depends on the number of plants per unit area and their individual productivity. The number of plants is mainly determined by the sowing rate. There are various recommendations for amaranth sowing rates, expressed either in weight (kg/ha) or in quantitative measures (million/ha). Most researchers indicate sowing rates in quantitative terms (Yaniuk & Hriunvald, 2022).

There are no clear recommendations regarding the plant density of amaranth. Some researchers (Shelest *et al.*, 2005; Duda & Kapshtyk, 2021) suggest cultivating amaranth with a sowing rate of 1.0 million/ha, which results in about 10 plants per 1 meter of the row. For optimal yield, it is recommended to have 100-150 thousand plants/ha. Mambetova & Sultanova (2022), in their studies on the growth and development of amaranth plants under different rates of organic and mineral fertilizers, used a sowing rate of 1 kg/ha for grain production and 2 kg/ha for animal feed.

According to Yeshitila *et al.* (2023) from Hawassa University (Ethiopia), in research evaluating the genetic diversity, heritability, and genetic progress for yield and yield-related traits of amaranth genotypes based on agromorphological characteristics, the plant density of amaranth was approximately 44,444 plants/ha, with a row spacing of 0.75 cm and a distance of 0.30 cm between plants within a row. On the other hand, there are research results recommending higher sowing rates for amaranth cultivation. Researchers from the Delta University research farm (Umeri *et al.*, 2022) used a plant density of 83,333 plants/ha in their field studies to assess the effect of urea on the growth and yield of *Amarathus hybridus*.

As noted by Toader *et al.* (2020) in their research on the morphology, biology, productivity, and yield quality of Amaranthus cruentus species, specifically two varieties “Bolivia 153” and “Golden Giant,” in terms of their adaptability to organic farming conditions in Romania, the plant density was 100,000 seeds/ha with a row spacing of 50 cm. Analysing the research data shows that plant density is an important integral indicator for determining the optimal sowing rate of amaranth. Pittelkow *et al*. (2019) observed that the productivity potential of amaranth BRS Alegria was achieved at plant densities of 24.2 and 22.8 plants/m^2 in Lucas do Rio Verde, Montana (Brazil).

In Nigeria, according to Idowu-Agida *et al*. (2020), amaranth seeds are sown in a scheme of 50 cm × 35 cm, and then, after two weeks of sowing, manual thinning is conducted, resulting in a plant density of 57,142 plants/ha. In Dudka's (2020) studies in the northern steppe, slightly higher sowing rates ranging from 0.75 to 1.50 kg/ha were investigated. The highest yield was achieved at a sowing rate of 1.0 kg/ha, with a plant density of 59.3 plants/m^2, resulting in a yield of 1.77 t/ha. Lykhochvor & Petrichenko (2022) report that the amaranth sowing rate varies from 0.3 to 1.0 kg/ha. For grain production, the optimal sowing rate is 300 g/ha (equivalent to 37 seeds/m^2 with a thousand kernel weight of 0.8 g, laboratory germination – 85%) and for green mass, 400 g/ha (equivalent to 50 seeds/m^2). The best plant density during growth and development is 10-25 plants/m^2.

In the conditions of the Western Forest-Steppe, amaranth holds great promise for cultivation, but its potential is still untapped due to the lack of well-adapted agricultural technologies suited to the soil and climatic conditions of the region. Therefore, at present, studying the impact of agronomic practices, particularly sowing rates, on the productivity of amaranth in the Western Forest-Steppe zone, is highly relevant, and this study aims to address this aspect.

MATERIALS AND METHODS

Field research was conducted at the experimental site of Lviv National University of Nature Resources to study the productivity of amaranth based on different sowing rates during the years 2020-2022. The soil of the experimental plot was dark grey podzolized loamy soil with a humus content of 2.3%. The content of readily hydrolysable nitrogen was 80-84 mg, available forms of phosphorus and potassium (according to Chirikov's method) were 108-114 mg and 98-108 mg/kg of soil, respectively. The soil solution had a near-neutral reaction, with a pH of the salt extract being 6.0.

The hydrothermal conditions during the study period deviated from the long-term average data, with slightly warmer temperatures and increased rainfall. In 2020 and 2022, the average temperature during the vegetation period was 15.3°C, which was 0.5°C higher than the long-term data. In 2021, it was 14.8°C, corresponding to the long-term average. The rainfall in 2020 exceeded the norm by 129 mm during the vegetation period, in 2021, it exceeded by 73 mm, and in 2022, by 28 mm.

The study was conducted with a plot area of 30 m^2, and the experiment was repeated four times. The plot arrangement was systematic. Six sowing rates were investigated: 0.2, 0.4, 0.6, 0.8, 1.0, and 1.2 million germinating seeds/ha. The amaranth variety used in the study was "Kharkivsky 1".

The cultivation technology included the following elements. Winter wheat was the preceding crop, and after harvesting it, the stubble was disc ploughed and harrowed. In the autumn, phosphorus, and potassium fertilizers ($P_{60}K_{120}$) were applied during ploughing. In spring, moisture was conserved using heavy harrows. Before sowing, N_{160} was applied as a pre-sowing cultivation. The amaranth seeds were sown in rows with row spacing of 45 cm and at a depth of 1 cm in the last decade of April in all three years of the study. The sowing was done using the Horsh Pronto 4 DS Seeder. To control weeds, inter-row cultivation and the herbicide Fusilade Forte (1.0 l/ha) were used. Spraying was carried out with a backpack sprayer at a rate of 200 l/ha of the working solution. Amaranth was harvested at full seed ripeness in the lower and middle parts of the panicle, and after drying, the amaranth was threshed.

The correlation-regression analysis and statistical processing of the data through the analysis of variance (ANOVA) were performed using the "Statistica 6.0" software. Data were compared using the Tukey's test. Statistically significant differences between samples were considered at $p<0.05$. The data in the tables are presented as the arithmetic mean with the standard deviation (x±SD).

RESULTS AND DISCUSSION

The structure of the agrophytocenosis of the amaranth crop consists of cultivated plants, weeds, microorganisms, and others. The type of agrophytocenosis, which determines the interrelationships both between individual amaranth plants and their dependence on other representatives of flora and fauna, is primarily influenced by field germination. Amaranth is a thermophilic crop with elevated temperature requirements, especially during the sowing and germination period. The specific plant requirements may vary and depend mainly on genetic characteristics. The highest temperatures during the years of the study were observed in May-April 2021, which could explain the highest level of field germination, reaching 65-76% (Table 1).

Table 1. *Field germination of amaranth depending on the sowing rate, %*

Sowing rate, million/ha of germinating seeds	Years			average
	2020	2021	2022	
0.2	66 ± 0.26ab	76 ± 0.26a	68 ± 0.41a	70

Table 1, Continued

Sowing rate, million/ha of germinating seeds	Years			average
	2020	2021	2022	
0.4	66 ± 0.42ba	73 ± 0.53b	65 ± 0.36b	68
0.6	63 ± 0.22c	68 ± 0.64cde	64 ± 0.50c	65
0.8	59 ± 0.50de	68 ± 0.50de	62 ± 0.58d	63
1.0	59 ± 0.52ed	67 ± 0.18edc	60 ± 0.29e	62
1.2	57 ± 0.41f	65 ± 0.39f	58 ± 0.29f	60

Note: *values that contain at least one identical letter in a table column are not different using the Tukey's test (p<0.05)*
Source: *the results of the authors' own research*

In 2020 and 2022, the reduced field germination can be attributed to colder temperatures. However, there was sufficient moisture throughout all three years, indicating that it was not a limiting factor. On average, over the three years, the highest field germination was achieved with the minimum sowing rate of 0.2 million seeds/ha, resulting in a 70% field germination. When the sowing rate was increased to 0.4 million seeds/ha, the field germination decreased to 68%, representing a 2% reduction compared to the 0.2 million seeds/ha rate. With the sowing rate of 0.6 million seeds/ha, the field germination dropped by another 3% compared to the previous variant. Furthermore, with sowing rates of 0.8, 1.0, and 1.2 million seeds/ha, the field germination continued to decline (63%, 62%, and 60%, respectively) with an increase in the number of sown seeds. The difference in field germination between the various sowing rate options was relatively small, at 10%.

The number of plants during the seedling stage varied significantly, ranging from 14 to 72 plants/m^2 (Fig. 1). The results of the correlation-regression analysis revealed a moderate inverse relationship between the sowing rate variants and the field germination of amaranth, with a correlation coefficient r=-0.69.

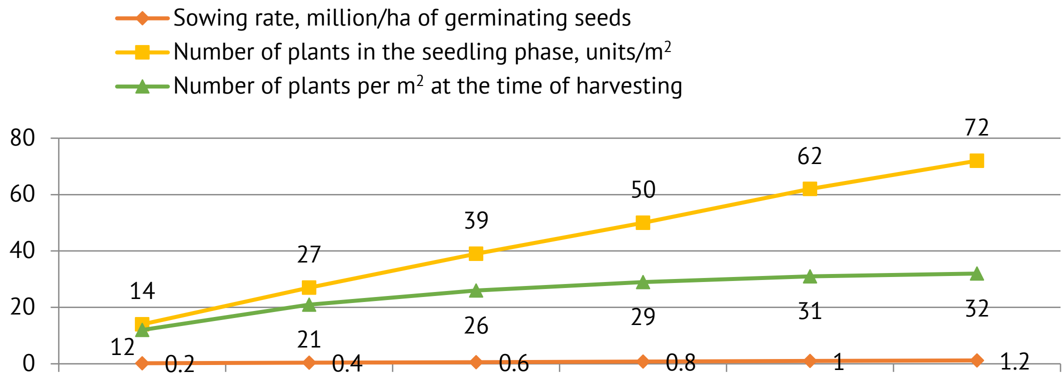

Figure 1. *Influence of sowing rates on the density of plants in the seedling phase and on the time of harvesting, average for 2020-2022*

The survival rate of plants during the vegetation period showed greater variability under the influence of sowing rates compared to field germination. A sizeable portion of plants perished due to intraspecific competition, especially evident in dense plantings and varying seed burial depths. Intense competition occurs during stem growth and vigorous vegetative mass accumulation. Well-developed plants absorb essential moisture and nutrients, outcompeting weaker plants and suppressing their growth by shading them from sunlight, eventually leading to their demise.

A direct correlation was established between sowing rates and the number of plants during the seedling stage, with a correlation coefficient r=1.00. Moreover, a very strong correlation was found between sowing rates and the number of plants/m^2 at the time of harvesting, with a correlation coefficient r=0.94. The survival rate of plants had a greater impact on plant density compared to field germination. Over the three-year period, the highest plant survival rate for amaranth was observed at the lowest sowing rate, reaching 86% (Table 2). Increasing the sowing rate to 0.4 million seeds/ha resulted in a decrease in the survival rate to 79%, and to 0.6 million seeds/ha, it dropped further to 67%. In dense plantings with sowing rates of 0.8, 1.0, and 1.2 million seeds/ha, the survival rate of amaranth plants from the seedling stage to harvesting was the lowest, at 58%, 51%, and 45%, respectively. The difference in survival rate between the variants with the lowest and highest sowing rates amounts to 41%.

Table 2. *Survival of plants during the growing season, %*

Sowing rate, million/ha of germinating seeds	Years				Increment
	2020	2021	2022	average	
0.2	81 ± 0.42a	90 ± 0.47a	87 ± 0.26a	86	41
0.4	76 ± 0.32b	83 ± 0.45b	78 ± 0.22b	79	34
0.6	64 ± 0.37c	72 ± 0.18c	65 ± 0.42c	67	22
0.8	55 ± 0.58d	64 ± 0.39d	55 ± 0.36d	58	13
1.0	47 ± 0.25e	56 ± 0.45e	50 ± 0.26e	51	6
1.2	41 ± 0.41f	51 ± 0.25f	43 ± 0.18f	45	–

Note: *values that contain at least one identical letter in a table column do not differ using Tukey's test (p<0.05)*
Source: *the results of the authors' own research*

As a result of the correlation-regression analysis, a very strong inverse relationship between sowing rates and the survival rate of amaranth plants during the vegetation period was established, with a correlation coefficient r=-0.97. Pelech (2021) noted a higher percentage of amaranth plant survival in the variant with a row spacing of 70 cm and the highest plant density before harvesting when sown with a row spacing of 45 cm, which in the conditions of 2020 and 2019 amounted to 52 and 68 plants/m^2, respectively, at the time of harvest.

The level of amaranth yield is most influenced by two crucial elements of the yield structure: the number of plants per unit area and the grain mass per plant. The sowing rate varied between variants by 20 seeds/m^2 and ranged from 20 to 120 seeds/m^2 (Table 3). The plant density before harvesting fluctuated within a much narrower range, ranging from only 12 to 32 plants/m^2 (Fig. 1). This can be attributed to the fact that in denser plantings, field germination slightly decreased, and the survival rate of plants from the seedling stage to harvesting sharply declined. In the studies by Zubillaga *et al.* (2020), increasing plant density led to a significant decrease in all biometric parameters determined during harvest collection. Intraspecific competition reduced plant height, panicle length, leaf and branch count, stem mass, and diameter, which reflected in smaller individual plant biomass. The reduction in photosynthate sources affected yield components (reduced weight and number of grains per plant) and consequently, the yield per plant. However, the greater number of plants compensated for the grain yield per hectare, although the seed cost and duration of the sowing cycle increased.

The seed mass per plant was highest in the variant with a sowing rate of 0.2 million seeds/ha and amounted to 34.1 g. The individual productivity of amaranth plants was highest in this variant, which can be explained by the fact that there were only 12 plants/m^2, allowing them to have the largest area for nutrient uptake and the best conditions for sunlight exposure and photosynthetic activity. With a sowing rate of 0.4 million seeds/ha, the seed mass per plant decreased to 20.4 g. Increasing the plant density further led to a continued decline in this parameter.

Table 3. *Elements of the structure of the amaranth harvest of the Kharkivskyi 1 variety depending on the sowing rate, the average for 2020-2022*

Sowing rate, million/ha of germinating seeds	Plant height, cm	Panicle length, cm	Weight of seeds per plant, g	Thousand kernel weight
0.2	182 ± 1.09 abcd	68 ± 0.22 a	34.1 ± 0.22 a	0.91 ± 0.010 ab
0.4	182 ± 1.00 bacd	67 ± 0.32 b	20.4 ± 0.36 b	0.91 ± 0.013 ba
0.6	180 ± 1.15 cdeab	64 ± 0.25 c	16.1 ± 0.14 c	0.88 ± 0.004 cd
0.8	180 ± 1.01decba	58 ± 0.34 d	14.1 ± 0.16 d	0.87 ± 0.012 dcef
1.0	178 ± 1.13ecd	53 ± 0.29 e	12.6 ± 0.22 e	0.86 ± 0.003 edf
1.2	170 ± 1.07 f	50 ± 0.18 f	11.7 ± 0.14 f	0.86 ± 0.003 fde

Note: *values that contain at least one identical letter in a table column do not differ using Tukey's test (p<0.05)*
Source: *the results of the authors' own research*

The results of the correlation-regression analysis revealed a strong and very strong inverse relationship between the sowing rates and yield structure indicators. Specifically, the correlation coefficient between the sowing rates and plant height was r=-0.85, between the sowing rates and seed mass per plant was r=-0.87, between the sowing rates and panicle length was r=-0.98, and between the sowing rates and thousand kernel weight was r=-0.95. A strong positive correlation was found between plant height and panicle length (r=0.85) and between plant height and thousand kernel weight (r=0.72), while a moderate positive correlation was observed between plant height and seed mass per plant (r=0.59). A strong positive correlation was also noted between panicle length and seed mass per plant (r=0.78) and between panicle length and thousand kernel weight (r=0.93).

The thousand kernel weight showed minor variation with changes in sowing rates, ranging from 0.86 to 0.91 g. An increase in the area available for nutrient uptake under lower sowing rates led to more vigorous growth and taller plants (by 12 cm). Panicle length also increased under variants with lower sowing rates, with the shortest length of 50 cm observed in the variant with the highest sowing rate of 1.2 million germinating seeds. Comparable findings were reported by Pittelkow *et al.* (2019) in their studies conducted in Brazil, where an increase in plant density from 30 to 62.5/m^2 resulted in reduced panicle weight.

According to Pelech (2021), the wide-row sowing method provided better conditions for the formation of yield components in amaranth. An important indicator, such as the thousand kernel weight, decreased as the inter-row spacing in the crops narrowed. Grain yield of amaranth varied under the influence of sowing rates. Under conditions of sufficient moisture, amaranth negatively responded to higher sowing rates and, consequently, crop densification. The lowest yield was observed with a sowing rate of 1.2 million seeds/ha, where it amounted to 3.76 t/ha (Table 4). Yield remained low also in the variant with a sowing rate of 1.0 million seeds/ha. With a sowing rate of 0.8 million seeds/ha, the yield increased by 0.2 t/ha compared to the sowing rate of 1.0 million seeds/ha. The same level of yield (4.09 t/ha) was recorded for the smallest sowing rate of 0.2 million seeds/ha.

Table 4. *Amaranth grain yield of the Kharkivskyi 1 variety depending on sowing rates, t/ha*

Sowing rate			Years				Increment	
pcs/m^2	million/ha	kg/ha	2020	2021	2022	Average	t/ha	%
20	0.2	0.19	3.70 ± 0.03 ad	4.52 ± 0.03 ad	4.05 ± 0.03 a	4.09	0.33	8.8
40	0.4	0.37	3.88 ± 0.04 bc	4.68 ± 0.03 b	4.28 ± 0.02 b	4.28	0.52	13.8
60	0.6	0.56	3.82 ± 0.04 cb	4.60 ± 0.02 da	4.20 ± 0.02 c	4.20	0.44	11.7
80	0.8	0.75	3.74 ± 0.02 da	4.45 ± 0.04 c	4.11 ± 0.03 d	4.10	0.34	9.0
100	1.0	0.93	3.60 ± 0.03 e	4.20 ± 0.02 e	3.90 ± 0.03 e	3.90	0.14	3.7
120	1.2	1.12	3.45 ± 0.03 f	4.02 ± 0.05 f	3.80 ± 0.02 f	3.76	–	–

Note: *values that contain at least one identical letter in a table column do not differ using Tukey's test ($p<0.05$)*
Source: *the results of the authors' own research*

According to the results of the correlation-regression analysis, a weak negative correlation was found between the sowing rate and the yield, with a correlation coefficient r=-0.46.

With an increase in the sowing rate, the survival rate of amaranth plants decreased, which is supported by the findings of Pelech (2021). During the full emergence period, the plant density per unit area was higher, by 16-33 plants/m^2, in the row sowing variant compared to the wide-row sowing, due to the higher sowing rate (100-110 thousand seeds/ha). During the harvesting period, the number of amaranth plants in the row sowing variant was 14 plants/m^2 lower (on average for years and varieties) compared to the wide-row sowing, resulting in 30-34% fewer plants being preserved.

The lowest yield in the study was obtained in 2020, which can be explained by specific hydrothermal conditions, namely excessive rainfall during two months – May and June. The excessive rainfall led to soil waterlogging, displacing air, and causing oxygen deficiency in the soil for the normal development of the root system, as well as increased weed infestation, ultimately resulting in a yield reduction. This is consistent with the findings of other researchers. Voropay *et al.* (2020) noted that during the vegetative period, the water requirements of amaranth and other crops change depending on their biological needs and current weather conditions. Critical periods for waterlogging include spring floods and summer-autumn floods, which reduced the yield of the studied crops in 2019.

The highest yields were achieved with sowing rates of 0.4 million seeds/ha and 0.6 million seeds/ha, amounting to 4.28 t/ha and 4.20 t/ha, respectively. This was 0.52 t/ha and 0.44 t/ha higher compared to the least productive variant. It should be noted that the highest yield was obtained with plant densities of 21 plants/m^2 and 26 plants/m^2, along with grain weights per plant of 0.91 g and 0.88 g. According to the findings of Niveyro

& Salvo (2017), the highest grain yield was obtained when sowing amaranth in wide rows with a spacing of 70 cm, resulting in an average yield of 23.2 kg/ha (across different varieties).

The results of Zubillaga *et al*. (2020) demonstrated the yield potential of *A. cruentus* in the lower valley of the Negra River, representing the southernmost density study conducted for this pseudo-cereal worldwide. The best plant density of 116,000 plants/ha with a row spacing of 0.70 m was established. This density allows for a crop from which optimal biological and economic yields can be obtained.

CONCLUSIONS

Increasing the sowing rate resulted in a systematic reduction in amaranth field germination. The highest field germination (70%) was observed for the lowest sowing rate of 0.2 million seeds/ha. For the sowing rate of 1.2 million seeds/ha, the stand density decreased to 60%, representing a 10% decrease.

The number of plants during the seedling stage increased with higher sowing rates, ranging from 14 plants/m^2 for the sowing rate of 0.2 million seeds/ha to 72 plants/m^2 for the sowing rate of 1.2 million seeds/ha, an increase of 58 plants. However, plant survival during the vegetative period significantly decreased with increased crop density, dropping from 86% for the sowing rate of 0.2 million seeds/ha to 45% for the sowing rate of 1.2 million seeds/ha. Consequently, the number of plants before harvest levelled out compared to the seedling stage, ranging from 12 to 32 plants/m^2, resulting in a reduced difference of 20 plants/m^2.

The highest grain yield was achieved with specific combinations of key crop structure elements: plant density per unit area of 21 plants/m^2 and 26 plants/m^2, and grain weight per individual plant of 20.4 g and 16.1 g, respectively. The highest grain yield for Amaranthus variety "Kharkivsky 1" was obtained with sowing rates of 0.4 million seeds/ha and 0.6 million seeds/ha, resulting in yields of 4.28 t/ha and 4.20 t/ha, respectively. Both increasing and decreasing the sowing rate led to a decline in grain yield.

The correlation-regression analysis revealed a strong and very strong inverse relationship between the sowing rates and crop structure indicators, and a weak inverse relationship between the sowing rate and grain yield. The established sowing rates for amaranth will be employed in further scientific research for the development and improvement of grain amaranth cultivation techniques in the conditions of the Western Forest-Steppe region.

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None.

CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

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Урожайність амаранту залежно від норми висіву

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Анотація. Головною цінністю амаранту є здатність нагромаджувати у зерні і листках велику кількість білка. За вмістом у насінні білка (15-18 %) амарант перевищує пшеницю (12-14 %), рис (7-10 %), кукурудзу (9-10 %) та інші зернові культури. Метою роботи було встановлення оптимальних норм висіву насіння амаранту в умовах зони Лісостепу західного України. У дослідженні використано загальнонаукові методи (аналіз, синтез, експеримент, опис, спостереження та порівняння), польові (фенологічні спостереження та облік), а також статистичні і кореляційно-регресійні аналізи обробки даних. Було досліджено норми висіву амаранту сорту Харківський 1 в умовах достатнього зволоження на темно-сірому опідзоленому ґрунті. Встановлено, що під впливом норм висіву змінювалась польова схожість. За норми висіву 0,2 млн/га вона становила 70 %, а за висівання 1,2 млн/га знизилась до 60 %, або на 10 %. На варіантах з вищими нормами висіву густота рослин була більшою. У фазі сходів за висіву 0,2 млн/га було 14 рослин, а за висіву 1,2 млн/га кількість рослин зросла до 72 шт/м^2. Виживання рослин за вегетаційний період різко зменшувалось при загущенні посівів: з 86% за норми висіву 0,2 млн/га до 45% за висіву 1,2 млн/га. Тому перед збиранням густота рослин вирівнялась, на м^2 12-32 було рослини. Оптимальним поєднанням основних елементів структури виявилось: 21 рослин/м^2 та 26 рослин/м^2 і маса зерна з однієї рослини 20,4 г та 16,1 г. Найвищу врожайність зерна амаранту сорту Харківський 1 одержано за норм висіву 0,4 млн/га та 0,6 млн/га – відповідно 4,28 т/га та 4,20 т/га. Збільшення чи зменшення норми висіву призводить до падіння рівня врожайності. Результати даного дослідження можуть використовуватися для подальшого встановлення та удосконалення основних елементів технології вирощування амаранту як науковими установами, так аграрними господарствами

Ключові слова: амарант; норма висіву; структура посівів; продуктивність
