UDC: 632.95:633.19
Doi: 10.56407/bs.agrarian/3.2025.82

Ukrainian Black Sea Region Agrarian Science
Vol. 29, No. 3

Establishment of effective chemical means of weed control in amaranth crops

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Abstract. The widespread introduction of amaranth into agricultural production in Ukraine, particularly in the sufficiently moist conditions of the Western Forest-Steppe, is hampered by a number of technological difficulties, one of the key ones being weed infestation of crops. The purpose of the study was to identify effective herbicides for weed control in amaranth crops in the conditions of the Western Forest-Steppe of Ukraine. Field studies to determine effective herbicides – promethrin (500 g/ha); clomazone (480 g/ha); fenmedifam (60 g/ha) + desmedifam (47 g/ha) + ethofumesate (75 g/ha) + lenacil (27 g/ha); fenmedifam (320 g/ha); triflusulfuron (500 g/ha); clopyralid (750 g/ha) on amaranth crops were conducted during 2021-2023 on the experimental field of the Department of Plant Growing Technologies of Lviv National University of Natural Resources under conditions of sufficient moisture. Control – variant with biological methods of weed control. It was found that all the herbicides studied were effective in controlling weeds. The lowest number of weeds was found in the variant using the herbicide prometrin (500 g/ha) – 1.6 pcs/m2, and the lowest weed weight was found when using the herbicide clopyralid, 750-108 g/m2. All herbicides under study had a suppressive effect on amaranth plants, as evidenced by the parameters of the crop structure. In particular, the panicle length was the longest in the control (64 cm) and decreased to 49-56 cm in the variants with herbicide application, the height was 32-52 cm shorter, and the weight of 1,000 seeds decreased to 0.68-0.80 g. All the herbicides under study also caused a decrease in amaranth yield by 0.40-1.37 t/ha due to the stress effect on the plants. The highest amaranth yield was obtained in the variant with biological weed control methods – 3.21 t/ha. In the variants using herbicides, the highest yield (2.81 t/ha) was provided by the pre-emergence herbicide prometrin at an application rate of 2 l/ha

Keywords: yield; herbicide; weight of 1,000 seeds; prometrin; Western Forest-Steppe

INTRODUCTION

Amaranth (*Amaranthus spp.*) is a highly productive crop with extremely valuable agronomic and biochemical properties, which is increasingly attracting the attention of Ukrainian farmers as a source of high-quality protein, oil, feed, and biomass. A particular feature of amaranth is its thermophilic nature and slow initial growth, which makes it especially vulnerable to weed competition during the first 3-5 weeks of the growing season. Yield losses due to weed infestation can reach 30-50%, especially in years with excessive spring rainfall. Weeds not only reduce yields but also hinder harvesting, degrade seed quality, and contribute to the

Article's History:
Received: 01.04.2025
Revised: 04.09.2025
Accepted: 30.09.2025

Suggested Citation:
Tyrus, M. (2025). Establishment of effective chemical means of weed control in amaranth crops. *Ukrainian Black Sea Region Agrarian Science*, 29(3), 82-90. doi: 10.56407/bs.agrarian/3.2025.82.

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development of diseases and pests. Therefore, there is an urgent need to identify the most effective and crop-safe herbicides that can provide reliable control of a wide spectrum of weeds without phytotoxic effects on amaranth. Given this context, research on herbicide protection in amaranth crops is of significant practical importance for developing effective cultivation technologies, reducing manual weeding labour, increasing yield stability, and enhancing the overall profitability of the crop.

As noted by E.V. Torres *et al*. (2024), amaranth has the potential to be a multipurpose crop of high value to the agro-industrial sector, serving as a source of protein, dietary fibre, antioxidants, and functional compounds for the food, pharmaceutical, and cosmetic industries. Particular attention was given to its agronomic traits, such as adaptability to adverse growing conditions, drought tolerance, and high biomass accumulation and grain yield. In the study by B. Mukuwapasi *et al*. (2024), amaranth was presented as a high-yielding, nutritious, and climate-resilient crop. Among its agronomic advantages are a short growing period, efficient water use, and resistance to biotic and abiotic stresses. The researchers emphasised that despite its adaptability to drought, high temperatures, and poor soils, and its exceptional nutritional value (high levels of protein, lysine, iron, and calcium), amaranth remains underutilised in agriculture across Africa, Asia, and other developing regions.

Ukrainian researchers T.I. Hoptsii *et al*. (2022) also highlighted the high potential of amaranth under climate change conditions, its drought tolerance, adaptability to light and moderately fertile soils, and the unique nutritional quality of its grain. Research conducted in the Poltava Oblast showed that domestically bred varieties provide grain yields of 2.1-2.7 t/ha, with high protein content (14-17%) and a favourable biomass ratio. T.I. Yaniuk & N.V. Grünwald (2022) stated that amaranth offers a promising alternative to traditional cereal crops in Ukraine due to its agronomic properties (resistance to temperature stress, high yield potential, and biological productivity) and nutritional benefits. Field studies of the influence of the characteristics of domestic varieties on the productivity of grain amaranth were conducted in the conditions of the Western Forest-Steppe of Ukraine. According to the studies, significant differences between the varieties were established in terms of biometric parameters of plants and grain yield. The varieties Kharkivskyi 1 and Lera demonstrated higher adaptability, greater biomass accumulation, and increased grain yield (over 2.5 t/ha) in the region under study (Tyrus & Lykhochvor, 2021).

However, the large-scale adoption of amaranth in agricultural production in Ukraine, particularly under the moderately humid conditions of the Western Forest-Steppe, is hindered by several technological challenges, among which weed infestation is one of the key issues. As a niche and relatively uncommon crop for industrial cultivation, no herbicides are currently registered for use on amaranth crops in either Ukraine or globally. According to N.I. Dudka (2020), weed control in amaranth fields primarily relies on biological methods, such as multiple shallow tillage operations before sowing, post-emergence harrowing, inter-row cultivation, and manual weeding. Mechanical weed control was also recommended by B. Melander & M.R. McCollough (2021). Given the botanical similarity between amaranth and sugar beet, the use of herbicides registered for sugar beet crops is suggested. These include Aramo 45, Betanal MaxxPro, Dual Gold, Caribou, Lontrel Grand, Pyramin Turbo, Frontier Optima, Fusilade Forte, etc. As of 2025, there were no registered herbicides for use in amaranth cultivation in Ukraine, therefore, the purpose of the study was to determine effective herbicides for weed control in amaranth crops under the conditions of the Western Forest-Steppe of Ukraine without negatively affecting the growth, development, and productivity of the crop.

MATERIALS AND METHODS

The research was conducted in 2021-2023 at the experimental field of the Department of Plant Production Technologies of Lviv National University of Life and Environmental Sciences. For the field trial, the preparations were taken that were experimentally established as the most tolerant to amaranth among 36 variants and provided positive results. The research scheme (Table 1) presented the most tolerant herbicides to amaranth, with the optimal application rate, established experimentally among 36 variants, and were appropriate for controlling the number of weeds.

Table 1. *Features of herbicide application in the experiment*

No.	Herbicide (Active ingredients, g/l; kg/ha)	Application rate	Due dates
1	Control	Two inter-row cultivation and manual weeding.	
2	Phenmedipham, 60 + Desmedipham, 47 + Etofumesate, 75 + Lenacil, 27	1.25 l/ha	After germination of amaranth in the cotyledon phase in weeds (BBCH 10)

Table 1, Continued

No.	Herbicide (Active ingredients, g/l; kg/ha)	Application rate	Due dates
3	Phenmedipham, 320	1.0 l/ha	2-6 leaves of amaranth (BBCH 12)
4	Prometrin, 500	2.0 l/ha	Immediately after sowing (BBCH 01)
5	Clomazone, 480	0.10 l/ha	Immediately after sowing (BBCH 01)
6	Triflusulfuron-methyl, 500	0.02 kg/ha	4-5 leaves of amaranth (BBCH 13)
7	Clopyralid, 750	0.1 kg/ha	4-5 leaves of amaranth (BBCH 13)

Note: *BBCH – system for uniformly coding phenologically similar stages of plant growth*
Source: *developed by the author*

The research compared the effectiveness of different herbicides by determining the residual weediness. The survey was carried out in the third ten days of July during the period of development of the largest mass of weeds. The soil of the experimental plot was dark grey podsolised with a humus content of 2.5%. The content of easily hydrolysed nitrogen was 78-84 mg, mobile forms of phosphorus and potassium (according to the Chirikov method) – 88-90 mg and 94-98 mg per 1 kg of soil, respectively. The reaction of the soil solution was close to neutral; the pH of the salt extract – -5.9-6.0 (DSTU 4115:2002, 2003). When analysing hydrothermal conditions over the study period, deviations from the long-term average were observed. The general trend was characterised by higher temperatures and increased precipitation. In 2021, there was sufficient moisture, but April was marked by temperatures below the long-term average. The following months – May, June and July – created favourable conditions for the emergence and development of amaranth seedlings. The weather conditions in 2022 were characterised by a cold April and a moisture deficit during the spring and summer period covering April, May, and June. In 2023, April was also marked by low temperatures, and May was characterised by insufficient rainfall. The situation changed significantly in the summer months, when in June and July, the average long-term precipitation rate was recorded by 24.4 and 31.7 mm above the long-term average, respectively. The experimental area was 10 m^2, the replication of the experiment was four-fold. Plots were placed systematically. 7 variants of weed control were investigated on the variety Kharkivskyi 1.

The amaranth's predecessor was winter wheat. After harvesting the predecessor, the field was disked and autumn ploughing was carried out and phosphorus and potash fertilisers – $P_{60}K_{120}$ were applied. At the first opportunity to enter the field, closed the moisture with the following two cultivations. Pre-sowing soil cultivation was carried out to the depth of seed placement, using the combined tool "Compactor" (Profi Stan). Nitrogen fertiliser (N_{160}) was applied in the spring for pre-sowing tillage. Seeds were sown in a row method to a depth of 2 cm in the third ten days of April in all three years of research. The seeding rate was 0.4 million/ha. A Horsch Pronto 4 DS seed drill was used. Harvesting of amaranth was carried out in two stages: mowing – in the phase of full seed ripeness in the lower and middle parts of the panicle, after drying the panicles of amaranth were threshed. The statistical data were processed through analysis of variance (ANOVA) in the Statistica 13 software. Comparisons between data sets were performed using the Tukey test. Differences among samples were deemed statistically significant at $p < 0.05$. The tabulated data were presented as arithmetic means accompanied by standard deviations ($x \pm$ SD). Correlation analysis based on Pearson correlation coefficients was conducted to test statistical hypotheses concerning the functional relationships between the experimental indicators. The strength and direction of relationships between variables were interpreted according to the standard scale ($r = \pm$ 0.1-0.3 – weak; ± 0.3-0.7 – moderate; ± 0.7-1.0 – strong). Regression equations and statistical models of the relationship between dependent and independent variables were created using "Statistica 13" software. The ethical guidelines for treating plants were followed during experimental research, including gathering plant material. The Convention on Biological Diversity (1992) provisions were met by the authors.

RESULTS AND DISCUSSION

In the conditions of sufficient moisture in the Western Forest-Steppe, the problem of weed infestation arises annually. The nature of weed infestation determines the ratio between the main biological groups of weeds, and the degree of weed infestation determines the number of weeds (pcs/m^2) and their weight (g/m^2). It should be borne in mind that a larger number of weeds per unit area with a small mass causes less damage to amaranth plants than a large mass of weeds even at a significantly lower density. In this study the number of weeds in the amaranth crops was low. The lowest number of them was in the variant with the use of the herbicide prometrin 1.6 pcs/m^2 (Fig. 1).

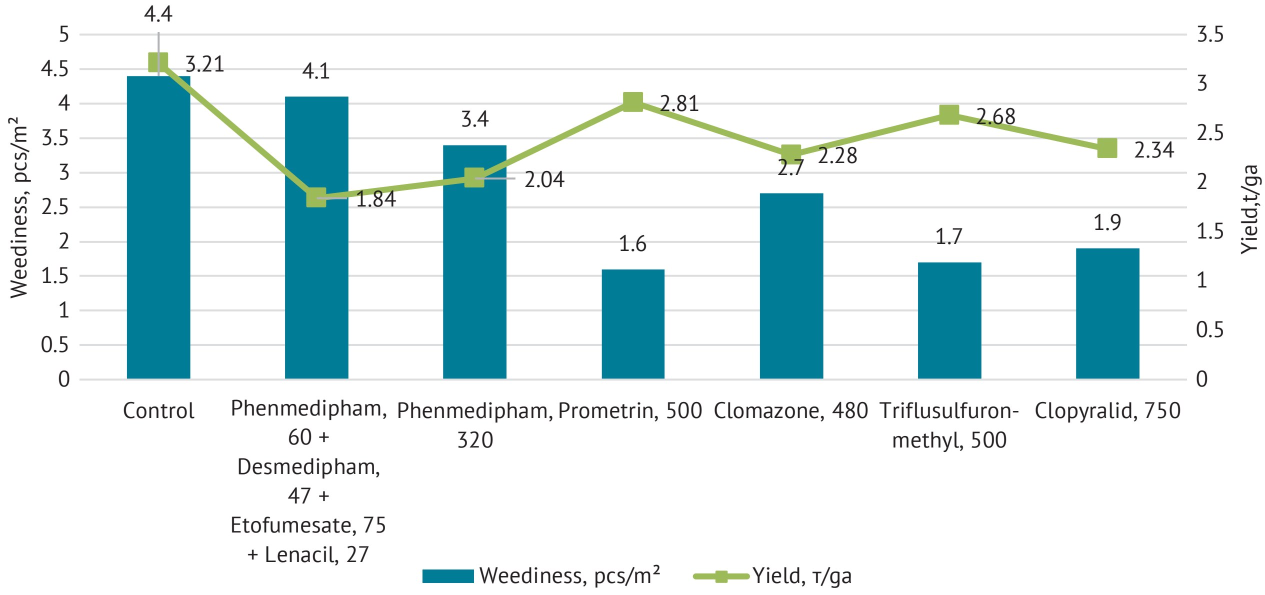

***Figure 1.** Effect of herbicide on weediness and yield of amaranth variety Kharkivskyi 1*
***Source:** developed by the author*

The statistical analysis revealed a strong inverse relationship between the number of weeds and the herbicide, with a correlation coefficient of $r = -0.91$ (Fig. 2). This pattern can be represented by a regression equation:

$$\text{Weediness},\ g/m^2 = 228.00 - 19.43 * \text{Herbicide}, \quad (1)$$

the coefficient of determination: $R2 = 0.83$.

This can be explained by the good effectiveness of herbicides in the first 40 days of the amaranth's vegetation. In addition, amaranth has a high ability to compete with weeds when it reaches the 10-leaf stage. The rapid development of sufficient optical density of amaranth crops allows reliably controlling the emergence of plants of repeated summer weeds. Herbicides of the betanal group in the second and third variants less effectively controlled the level of weeds and significantly suppressed amaranth plants. The weed weight was also lower when prometrin was applied (113 g/m^2), and the lowest when clopyralid was used (108 g/m^2) (Table 2).

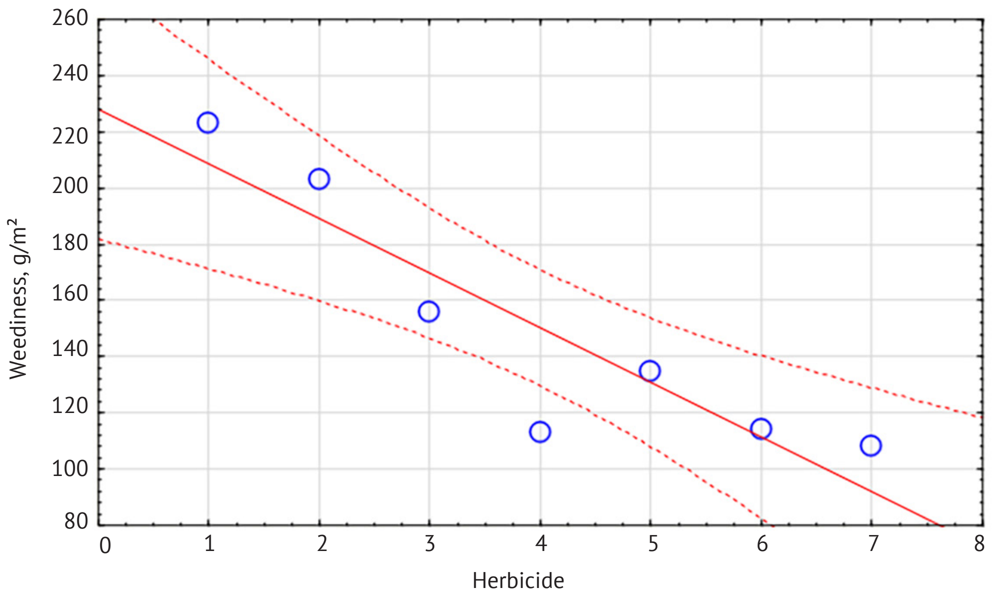

***Figure 2.** Statistical model of the herbicide effect on weed infestation of amaranth crop*
***Source:** developed by the author*

Table 2. *Level of weed infestation in amaranth crops depending on herbicide, average for 2021-2023*

Types of weeds	No.						
	1	2	3	4	5	6	7
Chenopodium album L.	0.5/30	0.1/16	0.8/32	-	0.1/14	-	0.3/24
Galium aparine L.	0.3/15	0.2/10	0.2/12	0.1/14	-	0.2/11	0.2/14
Thlaspi arvense L.	0.3/15	0.1/14	-	-	-	-	0.3/18
Sinapis arvensis L.	0.3/18	0.1/10	0.2/10	-	0.1/10	0.1/12	0.4/19
Tripleurospermum inodorum L.	0.5/25	0.4/21	0.6/24	0.1/10	0.2/12	0.1/12	-
Cirsium arvense L.	0.4/28	0.4/26	0.5/23	0.3/20	0.4/20	0.4/20	-
Sonchus oleraceus L.	0.4/22	0.3/19	0.3/21	0.2/16	0.2/17	0.3/18	-
Polygonum persicaria L.	0.4/18	1.4/40	0.2/14	0.2/20	0.5/19	0.1/12	0.2/15
Polygonum convolvulus L.	0.5/21	0.3/18	0.4/17	0.3/15	0.6/23	0.3/15	0.3/18
Polygonum scabrum Moench.	0.8/31	0.8/29	0.2/15	0.4/18	0.6/20	0.2/14	-
Total	4.4/223	4.1/203	3.4/156	1.6/113	2.7/135	1.7/114	1.9/108

Note: *numerator – pcs/m2, denominator – g/m2*
Source: *developed by the author*

The control was the weediest, with 4.4 plants per m^2 and a weight of 223 g/m^2. Notably, in the studies conducted there is no direct correlation between the weight and number of weeds and the yield of amaranth grain. Analysis of the elements of the yield structure clearly shows the suppressive effect of herbicides on amaranth plants. This was especially evident in the height of the plants. On the control without chemical weed control, the height of plants was much higher (220 cm) compared to other variants (Table 3).

Table 3. *Crop structure elements depending on herbicide, average for 2021-2023*

Herbicide	Plant height, cm	Panicle length, cm	Weight 1,000 seeds, g	Seed weight 1 plant, g
Control	220 ± 5.77a	64 ± 1.83a	18 ± 0.32a	0.84 ± 0.016a
Phenmedipham, 60 + Desmedipham, 47 + Etofumesate, 75 + Lenacil, 27	168 ± 3.65bcf	49 ± 0.82bcfg	10 ± 0.22b	0.68 ± 0.016bf
Phenmedipham, 320	170 ± 4.08cef	51 ± 0.82bcfg	12 ± 0.26c	0.73 ± 0.014cfg
Prometrin, 500	188 ± 4.4dg	56 ± 1.15de	16 ± 0.34de	0.80 ± 0.018de
Clomazone, 480	178 ± 3.74efg	56 ± 1.41de	16 ± 0.36de	0.78 ± 0.018dfg
Triflusulfuron- methyl, 500	171 ± 3.65bceg	51 ± 1.15bcfg	14 ± 0.34fg	0.70 ± 0.008bcef
Clopyralid, 750	180 ± 3.92gdef	51 ± 0.82bcfg	14 ± 0.36fg	0.74 ± 0.016ceg

Note: *values that have at least one identical letter within a table column do not differ when using the Tukey test ($p < 0.05$)*
Source: *developed by the author*

Thus, the difference between the control and the variant with the application of phenmedipham + desmedipham + etofumesate + lenacil herbicide was 52 cm. When using the herbicide prometrin, which was relatively tolerant to amaranth, the height of the plants was also 32 cm less. The length of the panicle was also the longest in the control (64 cm), and decreased to 49-56 cm in the variants with herbicides. The weight of grain per plant varied in a significant range and had a strong relationship with yield, as evidenced by the correlation coefficient $r = 0.87$. While in the variant without herbicide application, the grain weight was 18 g per plant, this figure decreased to 10 g with phenmedipham + desmedipham + etofumesate + lenacil due to the severe herbicide stress for amaranth plants. Herbicides also had a negative effect on the weight of 1,000 seeds. In the control, it was 0.84 g, and in the variants with chemical weed control, it decreased to 0.68-0.80 g. The reduction of all elements of the crop structure led to a natural decrease in the yield of amaranth grain, despite the fact that the level of weeds was lower when herbicides were applied. This was confirmed by the results of statistical analysis: a strong relationship was found between plant height, panicle length, weight of 1,000 seeds, and yield, where the correlation coefficient was $r = 0.84$, $r = 0.81$, $r = 0.76$, respectively. The herbicide phenmedipham + desmedipham + etofumesate + lenacil provided a certain control of weeds, but simultaneously, this variant had the lowest yield (1.84 t/ha) in the experiment (Table 4).

Table 4. *Grain yield of amaranth variety Kharkivskyi 1 depending on herbicide, t/ha*

No.	Herbicide	Years			Average for years, t/ha	Increase to control	
		2021	2022	2023		t/ha	%
1	Control	3.22±0.068a	3.35±0.048a	3.06±0.078a	3.21	-	-
2	Phenmedipham, 60 + Desmedipham, 47 + Etofumesate, 75 + Lenacil, 27	1.84±0.050b	1.92±0.054b	1.76±0.042bc	1.84	-1.37	-42.7
3	Phenmedipham, 320	2.12±0.047c	2.16±0.051c	1.84±0.068bc	2.04	-1.17	-36.4
4	Prometrin, 500	2.87±0.065d	2.91±0.071df	2.65±0.057df	2.81	-0.40	-12.5
5	Clomazone, 480	2.27±0.048eg	2.34±0.060e	2.23±0.050eg	2.28	-0.93	-29.0
6	Triflusulfuron-methyl, 500	2.71±0.056f	2.79±0.063fg	2.54±0.051df	2.68	-0.53	-16.5
7	Clopyralid, 750	2.39±0.056eg	2.43±0.039fg	2.20±0.104eg	2.34	-0.87	-27.1

Note: *values that have at least one identical letter within a table column do not differ when using the Tukey test ($p < 0.05$)*

Source: *developed by the author*

The herbicide phenmedipham + desmedipham + etofumesate + lenacil is widely used in sugar beet cultivation and is recommended in many recommendations for use in amaranth crops, but in studies it suppressed the crop plants and did not provide proper weed control. Visually, there was no burning of amaranth plants from the application of herbicides in any variant. However, the plants slowed down for some time in all variants compared to the control, which indicates that they were exposed to herbicide stress. The use of phenmedipham resulted in a sharp decrease in yield compared to the control by 1.17 t/ha, and it also proved to be quite stressful for amaranth. Prometrin herbicide proved to be the most tolerant to amaranth plants. The yield after its application was 2.81 t/ha. The highest yield (3.21 t/ha) was obtained in the control without the use of herbicides. The biological method of weed control was almost as effective as the chemical method, and the amaranth plants did not suffer from herbicide stress. The results of field experiments have shown that weeds can be effectively controlled using biological methods even in conditions of sufficient moisture. This allows producing environmentally friendly products with a much higher price and increasing the profitability of amaranth cultivation.

Amaranth had attracted growing attention as a promising crop due to its high nutritional value and adaptability to diverse environmental conditions. Despite its potential, the cultivation of amaranth faced a number of agronomic challenges, among which weed competition remained one of the most critical. However, there are a number of scientific papers on the resistance of Amaranthus weeds to several classes of herbicides. In particular, G.B.P. Braz & H.K. Takano (2022) conducted research focusing on the mechanisms of multiple resistance observed in Amaranthus species in different regions of the world and analysed the effectiveness of contemporary herbicides and combinations of active ingredients. Particular attention is paid to ways of reducing selective pressure on weeds, recommendations for herbicide rotation and integrated control methods. The review emphasised the importance of a comprehensive approach to managing resistant Amaranthus biotypes in agricultural systems, particularly in Brazil, where the problem is widespread. The study by X. Guo *et al.* (2024) investigated the effects of long-term use of the herbicide fomesafen on weeds, particularly *Amaranthus retroflexus* L. (common pigweed), in fields in China. The results showed that the systematic use of fomesafen led to the accumulation of *A. retroflexus* seeds in the soil, and a significant increase in its resistance to this active ingredient. Biological tests demonstrated that new generations of this weed had reduced sensitivity to fomesafen, indicating the development of resistance at the population level. The results of a study conducted by C.W. Beiermann *et al.* (2022) in the United States showed that post-emergence treatment (imazamox + bentazon) provided poor control of Palmer amaranth and did not result in a sustained reduction in Palmer amaranth density and biomass compared to the untreated control. Data on the presence of acetolactate synthase (ALS) inhibitor and glyphosate-resistant Palmer amaranth have been confirmed in Nebraska and are widespread in several counties (Mausbach *et al.*, 2021).

The study by D.I. Chaudari *et al.* (2019) presented results on the impact of integrated weed management on productivity development in grain amaranth (*Amaranthus hypochondriacus* L.) under conditions of South Gujarat, India. The field experiment included the use of pendimethalin (1.0 kg/ha a.i.) as a pre-emergence herbicide and quizalofop-p-ethyl (50 g/ha a.i.) as a post-emergence herbicide, combined with hand weeding. The highest grain yield (1,650 kg/ha) and net profit were achieved with the treatment involving pendimethalin followed by hand weeding on the 30th day after sowing. There is a significant lack of research on herbicide resistance in amaranth. Findings by P. Kudsk *et al*. (2012) demonstrated that amaranth is highly sensitive to herbicides targeting broadleaf weeds. Among the herbicides tested, amaranth tolerated only the active ingredients clomazone, clopyralid, phenmedipham, and triflusulfuron. Application of clomazone in the early post-emergence phase, instead of pre-emergence, ensured full crop tolerance even at the highest application rates. The post-emergence herbicides phenmedipham and triflusulfuron caused less crop injury at the 4-6 leaf stage compared to the 2-4 leaf stage, whereas clopyralid remained selective at both growth stages. J.S. Desai (2021) evaluated the effectiveness of integrated weed management in grain amaranth (*Amaranthus hypochondriacus* L.) at the experimental farm of Sardarkrushinagar Dantiwada Agricultural University. The results showed that the most effective approach was a combination of strategies, particularly inter-row cultivation 20-30 days after sowing along with the use of the herbicides pendimethalin and oxyfluorfen. This approach resulted in the lowest weed density and the highest grain yield (~1.5-1.7 t/ha). The researcher emphasised the value of an integrated method as a balance between effective weed control and reduced chemical load on the agroecosystem.

The effectiveness of biological weed control methods was confirmed by research conducted by scientists from various countries and soil-climatic zones. In a study by S. Deryło & Ł. Chudzik (2015), the impact of different primary soil tillage methods on the yield of cultivated amaranth (*Amaranthus hypochondriacus* L.) was investigated in Poland. The results showed that some fewer intensive methods, particularly shallow and disc tillage, can provide stable yields and help preserve soil moisture. Field experiments conducted in 2018 and 2019 in central Italy, which compared several mechanical weed control practices in grain amaranth (*Amaranthus cruentus* L.), demonstrated that selecting the optimal plant density and proper row spacing is also crucial for effective mechanical weed management (Casini & Biancofiore, 2020; Casini *et al.*, 2022). A field experiment conducted by J.S. Desai *et al*. (2023) at the Agricultural College Farm of SDAU compared 10 weed management strategies in grain amaranth (*Amaranthus hypochondriacus* L.), including herbicides (pendimethalin, oxadiargyl, oxyfluorfen), mechanical inter-row cultivation at 3-4 weeks after sowing, combined approaches, and weed-free control. The lowest weed density (4.07 plants/m^2) and minimum weed dry biomass (4.81 g/m^2) were recorded with oxyfluorfen (50 g/ha) combined with inter-row cultivation at the 4th week. Although the weed-free treatment was the most effective, the combination of herbicide and cultivation provided comparable efficacy with reduced labour input. This approach was deemed optimal under conditions of labour scarcity.

The benefits of combining chemical and mechanical weed control for increased productivity and profitability of grain amaranth under subtropical conditions were further supported by K. Patidar *et al.* (2024). The highest plant biomass, grain yield, and net returns were achieved with an integrated system: pre-sowing application of pendimethalin (1.0 kg/ha) + inter-row cultivation on day 30. While manual weeding was also effective, it required significantly more labour input. The study by S.R. Anand *et al.* (2025) examined the effect of different weed control methods on the growth and yield of grain amaranth (*Amaranthus hypochondriacus* L.) in North Indian conditions (Faizabad, Uttar Pradesh). The experiment included a comparison of hand weeding, inter-row cultivation, mulching and herbicide options. The highest yield and biomass were obtained when combining two-time hand weeding (20 and 40 days after sowing) with inter-row loosening. The results confirm the effectiveness of mechanical methods as an environmentally safe alternative to herbicides for amaranth.

CONCLUSIONS

All herbicides tested phenmedipham (60 g/ha) + desmedipham (47 g/ha) + etofumesate (75 g/ha) + lenacil (27 g/ha) (post-emergence); phenmedipham (320 g/ha) (post-emergence); prometrin (500 g/ha) (pre-emergence); clomazone (480 g/ha) (pre-emergence); triflusulfuron-methyl (500 g/ha) (post-emergence); clopyralid (750 g/ha) (post-emergence) were effective in controlling weeds. The lowest number of weeds was observed in the variant using the herbicide prometrin (500 g/ha) – 1.6 pcs/m^2. The weight of weeds was also lower when prometrin (500 g/ha) was applied – 113 g/m^2, and lowest when clopyralid herbicide was used, 750-108 g/m^2.

All the herbicides under study had a suppressive effect on amaranth plants, as evidenced by the yield structure parameters. In particular, the panicle length was the greatest in the control (64 cm) and decreased to 49-56 cm in the variants with herbicide application, while the height was 32-52 cm lower. Herbicides also had a negative effect on the weight of 1,000 seeds. In the control, it was 0.84 g, and in the variants with chemical weed control, it decreased to 0.68-0.80 g. In the variant without herbicides, the grain weight was 18 g per plant, while with the use of phenmedipham, 60 + desmedipham, 47 + etofumesate, 75 + lenacil, 27, this indicator was the lowest in the experiment – 10 g due to severe herbicide stress on amaranth plants. All the herbicides under study also caused a decrease in amaranth yield by 0.40-1.37 t/ha due to the stress effect on the plants. The highest yield of amaranth was formed in the variant without the use of herbicides with biological methods of weed control – 3.21 t/ha. In the variants with the use of herbicides, the highest yield (2.81 t/ha) was provided by the pre-emergence herbicide prometrin (500 g/ha) at an application rate of 2 l/ha. There is a need to continue investigating the specifics of herbicide use in amaranth crops, in particular, to clarify the active ingredients, rates, and timing of their application.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

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Встановлення ефективних хімічних засобів регулювання чисельності бур'янів в посівах амаранту

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Анотація. Широке впровадження амаранту у сільськогосподарське виробництво в Україні, зокрема в умовах достатнього зволоження Західного Лісостепу, стримується низкою технологічних труднощів, серед яких одним із ключових є забур'яненість посівів. Метою дослідження було визначення ефективних гербіцидів для боротьби з бур'янами в посівах амаранту в умовах Західного Лісостепу України. Польові дослідження з встановлення ефективних гербіцидів – прометрин (500 г/га); кломазон (480 г/га); фенмедіфам (60 г/га) + десмедіфам (47 г/га) + етофумезат (75 г/га) + ленацил (27 г/га); фенмедіфам (320 г/га); трифлусульфурон (500 г/га); клопіралід (750 г/га) на посівах амаранту проводили впродовж 2021-2023 рр. на дослідному полі кафедри технологій у рослинництві Львівського національного університету природокористування в умовах достатнього зволоження. Контроль – варіант з біологічними методами боротьби з бур'янами. Встановлено, що всі досліджувані гербіциди були ефективні щодо контролю бур'янів. Найменша кількість бур'янів була на варіанті з використанням гербіциду прометрин (500 g/ha) – 1,6 шт/м^2, а найнижча маса бур'янів за використання гербіциду клопіралід, 750-108 г/м^2. Всі досліджувані гербіциди виявляли пригнічувальну дію на рослини амаранту, про що свідчать параметри структури врожаю. Зокрема, довжина волоті була найбільша на контролі (64 см), і зменшувалася до 49-56 см на варіантах із застосуванням гербіцидів, висота була меншою на 32-52 см, маса 1000 насінин знизилась до 0,68-0,80 г. Всі досліджувані гербіциди внаслідок стресового впливу на рослини амаранту також спричинювали зменшення його врожайності на 0,40-1,37 т/га. Найвища врожайність амаранту формувалась на варіанті з біологічними методами боротьби з бур'янами – 3,21 т/га. На варіантах з використанням гербіцидів вищу урожайність (2,81 т/га) забезпечив препарат досходовий гербіцид прометрин за норми внесення 2 л/га

Ключові слова: врожайність; гербіциди; маса 1000 насінин; прометрин; Західний Лісостеп