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The impact of organic farming methods on weed infestation in corn crops and soil improvement

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ABSTRACT

This study evaluates the effectiveness of post–harvest oilseed radish green manures and different tillage methods in controlling potential soil contamination and weed infestation in typical chernozem soil and maize crops. It was found that the application of oilseed radish green manures significantly reduced the quantity of weed seeds in the 0–30 cm soil layer by 2.9–7.1 million seeds ha^{-1} compared to the non–green manure background. In maize fields, the population of all weed biological groups decreased by 0.2–4.5 individuals/m^2 and their biomass decreased by 4–69 g/m^2, resulting in an increase in grain yield by 1.5–1.8 t ha^{-1}. Substituting plowing with no–moldboard tillage for incorporating oilseed radish green manures reduced weed seed reserves in the 0–30 cm soil layer by 0.7–1.7 million seeds ha^{-1}. The deepest no–moldboard tillage provided the lowest potential contamination in the upper 0–5 cm soil layer, with 24.4 and 22.3 million seeds ha^{-1}, which was 0.6–1.1 and 2.3–3.3 million seeds ha^{-1} lower compared to no–moldboard tillage at 13–15 and 6–8 cm. Substituting plowing with no–moldboard tillage increased the number and biomass of weeds in maize crops, mainly due to early and late spring groups.

Keywords: green manure, agroecosystem, maize, tillage, weed infestation, yield, agrocoenosis.

INTRODUCTION

Effective weed management strategies are crucial for realizing the potential of agriculture in preserving ecosystem integrity and biodiversity, upon which we depend. The productivity of agricultural crops largely depends on the cleanliness of the crop agroecosystem. Maize cultivation requires diligent weed monitoring to achieve high yields. This is because maize crops, during their initial ontogenetic stages, slowly accumulate biomass and are unable to compete effectively with weeds for essential life factors [Farhood et al., 2015; Karbivska et al., 2022a]. Weeds quickly cover the bare surface of the field due to the prolonged emergence of crop seedlings – 7–10 days after sowing (for early planting dates), and the wide row spacing of 70 cm. Mass germination of weeds up to the 3–5 leaf stage of maize poses a threat to its normal growth and development. The dense cover of fast–growing weeds over the cultivated crop surface leads to shading, resulting in solar "starvation" of maize seedlings [Hutianskyi et al., 2022; Mishchenko et al., 2024].

The new paradigm suggests that weeds reduce yield by altering crop development rather than through direct competition for resources – at least in well–managed agroecosystems. Specifically, weeds reduce yield by initiating signaling processes early in the vegetative stage, shifting crop development from growth to defense, including responses to far–red light [Horvath et al., 2018; Horvath et al., 2022; Horvath et al., 2023]. Weeds quickly induce stress responses in maize, triggered when plants perceive a decrease in the ratio of red to far–red light, caused by the reflection of far–red light and absorption of red light by chlorophyll in neighboring weed plants [Legris et al., 2017; Casal et al., 2018; Horvath et al., 2019; Fernández–Milmanda et al., 2021].

Seeds detect weeds through chemical signals emitted by weeds [Ninkovic et al., 2019; Li et al., 2020; Huber et al., 2021]. Some weeds produce allelochemicals that can act as growth inhibitors of agricultural crops [Malinovsky et al., 2017; Kong et al., 2018; Tykhonova et al., 2021]. Overall, in agro–phytocenoses, a specific group of autotrophic weeds emerges, which, by competing with the main crop, significantly reduce yield and quality of the produced products [Dvorak, 2015; Kovalzhy et al., 2024]. With the intensive spread of agroecosystem contaminants, especially in moist years, the economic costs of weed control increase substantially [Price, 2013; McErlich, 2013; Petit et al., 2018]. Highly competitive weed species such as common lambsquarters, field bindweed, white goosefoot, and prostrate pigweed most strongly suppress the development of cultivated plants, reducing their yield and increasing the cost of the produced products [Petit et al., 2018; Hryhoriv et al., 2021].

A highly effective factor influencing weed development is dense green manureping with well–selected plants that provide high competition to weeds throughout their cultivation period. Intermediate green manures of oilseed radish are competitive to weeds, the suppression of which we evaluated in our studies of green manure incorporation methods.

MATERIAL AND METHODS

The research was conducted in the conditions of the Left–Bank Forest–Steppe of Ukraine in a stationary field experiment at the Department of Agrotechnologies and Soil Science based on the organic field of the Sumy National Agrarian University (50.881° N, 34.769° E). The soil of the research plot is typical chernozem, medium loamy, with low humus content in the forest, with humus content according to Tyurin of 3.2%, medium NPK content: mobile phosphorus content of 11.7–12.6, exchangeable potassium of 12.2–13.9 mg. 100 g^{-1} soil according to Chirikov, and hydrolyzable nitrogen according to Kornfield in Conway's cup – 16.5 mg. 100 g^{-1} soil. The reaction of the soil solution was determined potentiometrically by Kappen and was close to neutral (pH 5.9–6.2), and the hydrolytic acidity by Kappen was 1.2–1.4 mg/equivalent per 100 g soil.

The aim of our research was to compare the effectiveness of regulating potential and actual weed infestation in maize crops using methods of incorporating post–harvest oilseed radish green manures. The research tasks included studying the potential contamination of typical chernozem and actual weed infestation in maize crops after the application of post–harvest oilseed radish green manures and conducting different methods of primary soil tillage. Potential seed reserves were determined by washing the soil on sieves, and actual reserves were determined quantitatively and by weight. Maize was sown in short crop rotations after winter wheat. The experimental scheme had the following factor gradations:

Factor A – nutritional background. 1. Control (return of crop residues of winter wheat); 2. Green manure background (intermediate oilseed radish green manure). Factor B – soil tillage. 1. Control (plowing to a depth of 25–27 cm) (PN–3–35); 2. No–moldboard tillage to a depth of 25–27 cm (KLD–2.0); 3. No–moldboard tillage to a depth of 13–15 cm (AG–2.4); 4. No–moldboard tillage to a depth of 6–8 cm (AG–2.4).

Plot Establishment and Experimental Procedures. Plot establishment in the experiment was conducted by splitting method. Post–harvest oilseed radish green manure seeding was carried out from 2019 to 2021 at the beginning of August immediately after winter wheat harvesting. Green manure was incorporated into the soil during fall tillage operations, as prescribed by the experimental scheme, at the end of October. Maize was cultivated in 2020–2022 according to the recommended technology for the location of the experiment. The area of each experimental plot was 59 m².

RESULTS AND DISCUSSION

One of the main issues in herbology is determining the type of weed infestation in crops, the formation of which in maize agrocoenosis is influenced by its predecessor. In our research, winter wheat served as the predecessor of maize. After its harvest, at the time of main soil tillage, the type of weed infestation was determined to be low. In the control variant, the number of the specified group was 15.7 plants/m², with the majority of weeds belonging to the group of early spring annuals – 6.8 plants/m² (Table 1).

Table 1. Quantity and mass of weeds at the time of main soil tillage (average for 2019–2021)

Weed group	Number of eeeds			Weed mass		
	Control*, pcs./m²	Intermediate oilseed radish green manure		Control*, g/m²	Intermediate oilseed radish green manure	
		pcs./m²	% Before control		g/m²	% Before control
Annual early	6.8	3.1	–54.4	49.3	20.3	–58.8
Annual late	3.4	1.1	–67.6	32.7	9	–72.5
Overwintering	2.3	0.2	–91.3	18.2	2.2	–87.9
Perennial	3.1	0.9	–71.0	15.3	3.2	–79.1
Total	15.7	5.2	–66.9	115.5	34.7	–70.0

Note: *without post-harvest oilseed radish green manure seeding.

Compared to the control, in the variant with intermediate oilseed radish green manure cultivation, a significant decrease in weed quantity and considerable redistribution of structural units of herbological analysis in favor of early spring annuals were observed due to a significant decrease in the winter annuals group to 0.2 plants/m².

Structural analysis regarding weed mass formation in the control variant indicated the formation of this indicator in the winter annuals group up to 18.2 g/m², while the mass of early spring annuals was significantly higher at 49.2 g/m² and late spring annuals at 32.7 g/m².

Overall, the intermediate green manure reduced both the mass and quantity of weeds by 80.8 g/m² and 10.5 plants/m², respectively. The use of post–harvest green manures resulted in a reduction in the average weight per weed plant, thereby reducing their potential harmfulness to subsequent crop sowings.

Quantitative and weight indicators of weed infestation demonstrated that compared to the control, the highest significant decrease in both quantity and mass of early spring annuals was observed against the background of the green manure – by 3.7 plants/m² and 29 g/m², respectively, while the least difference in terms of quantity was observed in the winter annuals group – by 2.1 plants/m², and in terms of mass in perennial weeds – by 12.1 g/m².

A moderate inverse linear correlation was established between the amount of biomass formed by the oilseed radish green manure and the quantity and mass of weeds in it, described by correlation coefficients $r_{pcs.} = –0.75$ and $r_g = –0.73$, or determination coefficients of 0.56 and 0.53, respectively. After the incorporation of the intermediate green manure, during the restoration of spring vegetation, a uniform distribution of weed seeds in the soil root layer 0–30 cm was observed after plowing within 30–39 million seeds ha^{-1} (Table 2).

Compared to moldboard tillage, significant increases in the number of weed seeds in the upper soil layers 0–5 and 5–10 cm were noted for

Table 2. Potential soil contamination under the influence of the green manure and its incorporation method during vegetation restoration (average for 2020–2022)

Experimental variant		Soil layer, cm				Total
Nutritional background	Soil tillage	0–5	5–10	10–20	20–30	0–30
Without green manure	Plowing to 25–27 cm (control)	19.5	18.4	35.4	29.5	102.8
	No-moldboard tillage to 25–27 cm	23.3	33.2	25.1	21.4	103.0
	No-moldboard tillage to 13–15 cm	24.4	34.9	22.9	21.2	103.4
	No-moldboard tillage to 6–8 cm	26.6	33.2	22.3	21.1	103.2
Green manure background	Plowing to 25–27 cm (control)	19.0	17.8	35.0	29.2	101.0
	No-moldboard tillage to 25–27 cm	22.3	32.3	24.6	21.1	100.3
	No-moldboard tillage to 13–15 cm	22.9	33.9	22.4	20.9	100.1
	No-moldboard tillage to 6–8 cm	24.6	32.1	21.8	20.8	99.3
$LSD^*_{05\ Green\ manure\ /\ Tillage}$		0.1/0.5	0.2/0.7	0.2/0.5	0.3/0.7	0.3/0.5

Note: *LSD – least significant difference.

no–moldboard tillage by 3.3–7.1 and 14.3–16.5 million seeds ha^{-1}, respectively, with significant decreases in layers 10–20 and 20–30 cm (by 10.2–13.2 and 8.1–8.5 million seeds ha^{-1}). This is due to the absence of inversion and mixing of the entire root–containing 0–30 cm soil layer under no–moldboard tillage. Overall, there was a reduction in weed seed reserves by 0.7–1.7 million seeds ha^{-1} with the replacement of plowing with no-moldboard tillage on the green manure background.

When considering the influence of tillage depth, it was found that with shallow no–moldboard tillage (6–8 cm), the largest weed seed reserves were formed in the 0–5 cm soil layer – 26.6 and 24.6 million seeds ha^{-1}. Weed seed reserves in the 10–20 cm and 20–30 cm layers were the lowest here – 21.1 and 20.8 million seeds ha^{-1}, respectively. This is explained by the absence of mechanical loosening in the lower layers under shallow tillage.

During no-moldboard tillage at 13–15 cm soil depth, deeper mechanical loosening occurred, resulting in a significant decrease in weed seed quantity compared to previous tillage for both nutritional backgrounds in the 0–5 cm soil layer by 2.2 and 1.7 million seeds ha^{-1}, respectively, and an increase in the 5–10 cm and 10–20 cm layers by 1.7–1.8 and 0.6 million seeds ha^{-1}, respectively.

The deepest no–moldboard tillage in the study provided the lowest potential soil contamination in the 0–5 cm soil layer – 24.4 and 22.3 million seeds ha^{-1}, which was 0.6–1.1 million seeds ha^{-1} less compared to no–moldboard tillage at depths of 13–15 and 6–8 cm, respectively. Thus, increasing the depth of no-moldboard tillage contributes to reducing the potential contamination of the upper soil layers and reduces the likelihood of weed emergence, as also reflected in the publications of several scientists [Scherner et al., 2016; Karbivska et al., 2022b].

In our research, the depth of no-moldboard tillage closely correlated with the quantitative distribution of weed seeds in soil layers. A moderate inverse linear relationship (r = –0.75, r2 = 0.59) was established during vegetation restoration in the 0–10 cm soil layer and a high direct relationship was observed in the 10–20 cm (r = 0.97, r2 = 0.95) and 20–30 cm (r = 0.84, r2 = 0.71) layers.

Oilseed radish green manure on all tillage variants, compared to the non-green manure background, contributed to a significant reduction in potential weed infestation up to a depth of 20 cm by 1.5–3.6 million seeds ha^{-1}. In the 20–30 cm soil layer, potential contamination decreased by 0.3 million seeds ha^{-1} (Table 1).

Overall, in the 0–30 cm soil layer, potential contamination decreased by 2.9–7.1 million seeds ha^{-1} due to the application of oilseed radish green manure. Increasing the biomass of oilseed radish reduces potential soil contamination, as evidenced by the inverse correlation between weed seed quantity and green manure biomass at a significance level of 71–74%.

It was found that when cultivating maize, potential soil contamination of the upper layers

Table 3. Impact of green manure and tillage on weed quantity and mass dynamics in maize crops (average for 2020–2022)

Experimental variant		Weed quantity, plants			Weed mass, g		
Nutritional background	Soil tillage	At emergence	At appearance of tassels	At harvest	At emergence	At appearance of tassels	At harvest
Without green manure	Plowing to 25–27 cm (control)	14.3	19.8	8.8	89.6	581.0	427.4
	No-moldboard tillage to 25–27 cm	15.7	22.6	9.7	91.0	662.8	470.2
	No-moldboard tillage to 13–15 cm	19.3	27.7	11.8	110.4	785.3	595.2
	No-moldboard tillage to 6–8 cm	22.5	32.9	14.8	125.9	942.5	650.6
Green manure background	Plowing to 25–27 cm (control)	8.3	15.0	3.8	84.9	534.7	262.4
	No-moldboard tillage to 25–27 cm	8.8	15.9	4.4	79.1	600.9	295.0
	No-moldboard tillage to 13–15 cm	13.5	21.7	6.8	98.3	721.8	355.8
	No-moldboard tillage to 6–8 cm	17.0	26.2	9.9	110.7	799.9	478.4
$LSD_{05\ Green\ manure\ /\ Tillage}$		0.5/0.6	1.0/1.4	0.5/0.7	1.9/2.7	27.7/39.1	20.9/29.3

determined the actual weed infestation [Scherner et al., 2016; Voitovyk et al., 2023; Hryhoriv et al., 2024]. Since the lowest amount of upper layer weed seeds was observed in the variant with green manure incorporation by plowing, it is understandable that this variant also had the lowest quantity and mass of weeds in the crops – 8.8–19.8 plants/m² and 89.6–581.0 g/m², respectively (Table 3). The variant with deep (25–27 cm) no–moldboard tillage was closest in actual weed infestation to plowing. The difference in weed quantity between them was insignificant. When cultivating maize after shallow (13–15 cm) no-moldboard tillage, the quantity increased significantly – by 5.0–20.8 plants/m² and weed mass increased by 33.0–346.8 g/m² compared to plowing and deep no–moldboard tillage on both nutritional backgrounds.

Highest actual weed infestation when growing maize was observed with the shallowest no–moldboard tillage at a depth of 6–8 cm; compared to other tillage methods, it significantly increased, both in terms of weed quantity – up to 17.0–32.9 plants/m², and their mass – up to 110.7–942.5 g/m².

The lowest weed quantity was recorded at the time of maize harvest – 8.8–11.8 plants/m², which was due to the fading of waves of their appearance. The lowest weed mass was found at the time of maize emergence – 84.9–125.9 g/m², which was associated with their short vegetation period, interrupted by mechanical loosening during crop care. A moderate inverse correlation between actual maize crop weed infestation and the depth of no-moldboard tillage was established, specifically for weed quantity r = –0.68, and for their mass r = –0.66.

The reduction in weed population during maize cultivation under green manure was most pronounced with no–moldboard tillage at a depth of 25–27 cm (by 5.3–6.9 plants/m²), and weed mass reduction was most significant with the shallowest tillage at 6–8 cm (by 15.2–172 g/m²). Underneath maize, these no-moldboard tillage depths of 25–27 cm and 6–8 cm showed the strongest inverse correlation between green manure biomass and weed quantity, with r = –0.76 and –0.75, and their mass with r = –0.59 and –0.55.

The use of oilseed radish green manure led to a significant reduction in the quantity of all weed biological groups (by 0.2–4.5 plants/m²) and their mass (by 4–68 g/m²) during maize cultivation (Table 4). The use of green manure most effectively reduced the quantity and mass of late spring weeds during maize cultivation – by 3.0–4.5 plants/m² and 42–68 g/m² respectively, and the difference from the control background for perennial weeds was minimal – 0.2–0.4 plants/m² and 4–9 g/m². Replacing plowing with no–moldboard tillage increased the quantity and mass of weeds in maize crops mainly due to the spring and late spring groups. A negligible difference compared to plowing in quantity (0.1–0.9 plants/m²) and mass (2–24 g/m²) of weeds was observed with no–moldboard tillage at a depth of 25–27 cm.

When reducing the depth of no–moldboard tillage to 13–15 cm, a negligible increase in the quantity of winter (by 0.5–0.7 plants/m²) and perennial (by 0.3–0.4 plants/m²) weeds and mass of perennial weeds (by 5–6 g/m²) was observed compared to the plowing variant. With no–moldboard tillage at a depth of 6–8 cm, the quantity and mass of all weed biological groups significantly increased under both nutritional backgrounds. The formation of the lowest weed infestation level in maize resulted in the highest crop yields – 7.7 and 7.9 t ha^{-1} for plowing and no-moldboard tillage at a depth of 25–27 cm under the post–harvest oilseed radish green manure background (Fig. 1).

Reduction in the depth of no–moldboard tillage and the absence of intermediate oilseed radish green manure significantly reduced maize grain yield – by 0.5–1.0 t ha^{-1} and 1.5–1.8 t ha^{-1}, respectively. The economic threshold of weed infestation for maize ranges from 5–12 plants/m² for annuals to 2–4 plants/m² for perennials. Total maize yield losses in the presence of 50 plants/m² weeds in its crops range from 20 to 25%. With a higher level of infestation, yield losses can reach 75% [Petit et al., 2018].

Without identifying and eliminating the primary causes of weed spread, taking into account phytocenotic interactions between plants, effective control of typical agrocenosis contaminants is impossible. It is known that weed spread in crops is directly determined by the potential seed reserves in the soil, gradually increasing, including under the conditions of the Ukrainian Forest–Steppe, reaching a level of 3–4 billion seeds ha^{-1} in the soil layer of 0–30 cm [Santín-Montanyá et al., 2016; Melander et al., 2017]. One way to reduce weed seed reserves is to stimulate their germination and intensify processes of organic matter biological decomposition, which enhances soil microbiological activity [Cordeau et al., 2017; Kolisnyk et al., 2024]. These processes are significantly activated by combining green manure background and no–moldboard soil tillage

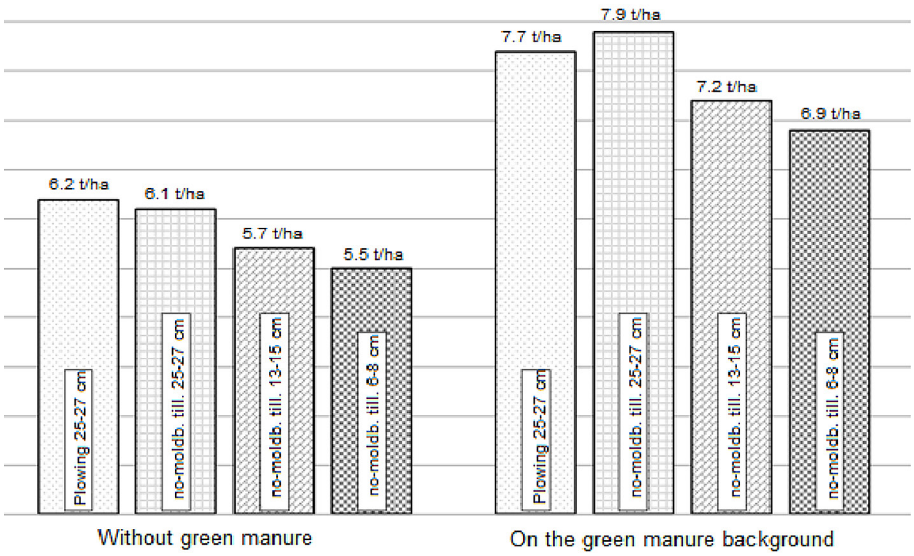

Figure 1. Influence of nutrition background on maize grain yield for different methods of primary soil tillage, t ha^{-1}

[Kołodziejczyk, 2015; Kunz et al., 2016]. Sowing green manures during their vegetation suppresses annual weeds with dense vegetation cover, preventing them from forming seeds [Jabran et al., 2015; Jabran et al., 2016]. Green manure mycorrhiza and their incorporated biomass activate soil biota activity, including biological predators, intensifying predation on weed seeds, ultimately reducing their longevity and similarity in crops of subsequent crops [Voytovyk et al., 2024].

Integrated weed management currently does not include options based on biodiversity, enhancing biological weed regulation. Managing agrocenosis by enriching crop rotations with intermediate green manures creates biotic interactions that can significantly alter weed species development at various stages of their life cycle [Petit et al., 2018]. Through optimization of soil nutrient, water, and air regimes, green manures also stimulate the growth and development of cultivated plants, promoting their successful competition with weeds [Kołodziejczyk, 2015].

High weed control effectiveness of green manures and oilseed radish mulch has been demonstrated in studies by several researchers [Lawley et al., 2011; Kołodziejczyk, 2015]. Scientific publications by researchers [Cordeau et al., 2017; Melander et al., 2017] substantiate the use of plowing as an effective element of crop cultivation technology, which evenly distributes weed seeds in the treated soil layer. Prolonged no–moldboard tillage concentrates the majority of similar weed seeds closer to the soil surface. In particular, shallow and surface tillage with disc implements leads to the accumulation of weed seeds mainly in the soil layer of 0–5 cm, while deep no–moldboard loosening with flat–cutting implements promotes their partial penetration deeper than 5 cm [Mishchenko et al., 2022; Kovalenko et al., 2024].

With plowing, fewer weed seedlings appeared in maize crops than with no-moldboard tillage. However, the application of modern agronomic measures – harrowing and inter-row cultivation – ensures effective removal of emerged weeds in maize crops. With timely destruction of growing weeds, no-moldboard tillage, compared to plowing, creates conditions for more intensive reduction of potential soil contamination, which will subsequently determine the actual weed infestation of subsequent crops [Scherner et al., 2016; Karbivska et al., 2023].

Weed infestation in maize crops increased until mid–vegetation, with the appearance of the second wave of weeds, confirming the findings of other researchers [Armengot et al., 2016; Dvořák et al., 2016]. This is associated with maize's low competitiveness against weeds, which in the first half of the vegetation period have optimal conditions of moisture and warmth in the Ukrainian Forest–Steppe for the emergence and development of their seedlings.

The obtained data indicate a decrease in the quantity and mass of annual grassy weeds on the oilseed radish green manure background, and such a change in weed infestation structure can be explained by the fact that oilseed radish, as a representative of the Brassicaceae family, contains glucosinolate compounds that hydrolyze to form toxins for annual grassy weeds [Jabran et al., 2015].

Some researchers emphasize that in order to achieve effective weed control, a weed control strategy that involves leaving mulch on the soil surface should be applied. Weed growth was significantly suppressed in the corn rows by the cover crops of common rye and annual ryegrass during the first 16 days after corn emergence. This effect had a decreasing trend until day 28. The inhibition of plant and weed growth from annual ryegrass residues is due to the presence of phenolic acids and benzoxazolin-2(3H)-one in the filtrate extracts [Bezuidenhout et al., 2012].

Encouraging weed control results were obtained when using hairy vetch mulch (*Vicia villosa* Roth.). The cover crop of vetch formed a large biomass of mulch in September and provided the best weed control in the following spring. This vetch mulch reduces the need for soil tillage for a period of 1.5 to 2 years [Halde et al., 2014]. Sowing cover crop mixtures is more effective than single-species sowing. A steady, albeit decreasing, reduction in weed biomass is evident for some time after the cover crops are discontinued [Dong et al., 2024]. Deep no–moldboard tillage of the oilseed radish green manure background results in crop plantings having higher competitiveness against weeds and better soil fertility parameters, forming significantly higher crop yields compared to plowing [Mishchenko et al., 2022; Radchenko et al., 2023].

Thus, the combined application of effective biodiversity regulation factors in crop rotation – post-harvest green manureping and no-moldboard tillage – provides conditions for reducing the development and spread of weeds in maize agrocenosis.

CONCLUSIONS

Based on herbological monitoring of maize crops, it was found that the highest weed control effectiveness was achieved with post-harvest cultivation of oilseed radish green manure and the application of no–moldboard tillage to a depth of 25–27 cm. This option led to a significant reduction in potential soil contamination in the 0–30 cm soil layer. No-moldboard tillage of the oilseed radish green manure background to a depth of 25–27 cm resulted in the lowest weed seed concentration in the 0–10 cm soil layer compared to shallower tillage. The green manure background significantly reduced the quantitative-weighted weed infestation in maize crops. The actual weed infestation with deep no-moldboard tillage of the green manure background was at the level of plowing and significantly lower compared to shallow no-moldboard tillage. Conducting no–moldboard tillage to a depth of 25–27 cm on the oilseed radish green manure background resulted in high agronomic efficiency, manifested by obtaining the highest maize grain yield in the study – 7.9 t ha^{-1}.

REFERENCES

1. Armengot L., Blanco-Moreno J.M., Bàrberi P., Bocci G., Carlesi S., Aendekerk R. & Sans F.X. (2016). Tillage as a driver of change in weed communities: a functional perspective. *Agriculture, Ecosystems & Environment, 222*, 276–285. https://doi.org/10.1016/j.agee.2016.02.021
2. Bezuidenhout S.R., Reinhardt C.F. & Whitwell M.I. (2012). Cover crops of oats, stooling rye and three annual ryegrass cultivars influence maize and Cyperus esculentus growth. *Weed Research, 52*, 153–160. https://doi.org/10.1111/j.1365-3180.2011.00900.x
3. Casal J.J. & Qüesta J.I. (2018). Light and temperature cues: multitasking receptors and transcriptional integrators. *New Phytologist., 217*, 1029–1034.
4. Cordeau S., Smith R., Gallandt E., Brown B., Salon P., Di Tommaso A. & Ryan M. (2017). Timing of tillage as a driver of weed communities. *Weed Science, 65*(4), 504–514. https://doi.org/10.1017/wsc.2017.26
5. Dong F., Zeng W. (2024). Effects of fall and winter cover crops on weed suppression in the united states: A meta-analysis. Sustainability, 16, 3192. https://doi.org/10.3390/ su16083192
6. Dvořák P., Tomášek J., Hamouz K. & Kuchtová P. (2016). Reply of mulch systems on weeds and yield components & nbsp; in potatoes. Plant, Soil and Environment, 61(7), 322–327. https://doi.org/10.17221/242/2015-pse
7. Farhood Y., Saeed Z.S., Ghassem A., Farideh S. & Vahid B. (2015). Effects of cover crops and weed management on corn yield. *Journal of the Saudi Society of Agricultural Sciences, 14*(2), 178–181. https://doi.org/10.1016/j.jssas.2014.02.001
8. Fernández-Milmanda G.L. & Ballaré C.L. (2021). Shade avoidance: expanding the color and hormone palette. *Trends in Plant Science, 265*, 509–523.
9. Halde C., Gulden R.H., Entz M.H. (2014). Selection of mulch for cover crops for organic rotational systems No-till in Manitoba, Canada. *Agronomy Journal, 106*(4), 1193–1204. https://doi.org/10.2134/agronj13.0402

10. Horvath D., Bruggeman S., Moriles-Miller J., Anderson J., Dogramaci M., Scheffler B. & Clay S. (2018). Weed presence altered biotic stress and light signaling in maize even when weeds were removed early in the critical weed-free period. *Plant Direct, 2*(4), e00057. https://doi.org/10.1002/pld3.57
11. Horvath D., Clay S., Bruggeman S., Anderson J., Chao W. & Yeater K. (2019). Varying weed densities alter the corn transcriptome highlighting a core set of weed-induced genes and processes with potential for manipulating weed tolerance. *The Plant Genome, 12*(3), 1–9. https://doi.org/10.3835/plantgenome2019.05.0035
12. Horvath D., Clay S., Swanton C., Anderson J. & Chao W. (2022). Weed-induced crop yield loss: a new paradigm and new challenges. *Trends in Plant Science, 28*, 567–582. https://doi.org/10.1016/j.tplants. 2022.12.014
13. Horvath D., Doherty C., Desai J., Clark N., Anderson J. & Chao W. (2023). Weed-induced changes in the maize root transcriptome reveal transcription factors and physiological processes impacted early in crop-weed interactions. *AoB Plants, 15*(3), plad013. https://doi.org/10.1093/aobpla/plad013
14. Hryhoriv Y., Butenko A., Nechyporenko V., Lyshenko M., Ustik T., Zubko V., Makarenko N., Mushtai V. (2021). Economic efficiency of Camelina sativa growing with nutrition optimization under conditions of Precarpathians of Ukraine. Agraarteadus, 32(2), 232–238. https://doi.org/10.15159/jas.21.33
15. Hryhoriv Y., Butenko A., Solovei H., Filon V., Skydan M., Kravchenko N., Masyk I., Zakharchenko E., Tykhonova O., Polyvanyi A. (2024). Study of the impact of changes in the acid-base buffering capacity of surface sod-podzolic soils. *Journal of Ecological Engineering, 25*(6), 73–79. https://doi.org/10.12911/22998993/186928
16. Huber M., Nieuwendijk N., Pantazopoulou C. & Pierik R. (2021). Light signalling shapes plant–plant interactions in dense canopies. *Plant Cell Environment, 44*, 1014–1029.
17. Hutianskyi R., Popov S., Zuza V. & Kuzmenko N. (2022). Weediness of corn for grain crops by cultivation in the stationary crop rotation and permanent crops in the Eastern Forest Steppe of Ukraine. *Quarantine and Plant Protection, 3*, 15–19. doi.org/10.36495/2312-0614.2022.3.15-19
18. Jabran K., Cheema Z.A., Khan M.B. & Hussain M. (2016). Control of cabbage aphid brevicoryne brassicae (Homoptera: Aphididae) through allelopathic water extracts. Pakistan journal of scientific and industrial research. *Series B: Biological Sciences, 59*, 48–51.
19. Jabran K., Mahajan G., Sardana V. & Chauhan B.S. (2015). Allelopathy for weed control in agricultural systems. Crop Protection, 72, 57–65. https://doi.org/10.1016/j.cropro.2015.03.004
20. Karbivska U., Asanishvili N., Butenko A., Rozhko V., Karpenko O., Sykalo O., Chernega T., Masyk I., Chyrva, A., Kustovska A. (2022b). Changes in agrochemical parameters of sod-podzolic soil depending on the productivity of cereal grasses of different ripeness and methods of tillage in the Carpathian Region. *Journal of Ecological Engineering, 23*(1), 55–63. https://doi.org/10.12911/22998993/143863
21. Karbivska U., Masyk I., Butenko A., Onychko V., Onychko T., Kriuchko L., Rozhko V., Karpenko O., Kozak M. (2022a). Nutrient balance of sod–podzolic soil depending on the productivity of meadow agrophytocenosis and fertilization. *Ecological Engineering & Environmental Technology, 23*(2), 70–77. https://doi.org/10.12912/27197050/144957
22. Karbivska U., Butenko A., Kozak M., Filon V., Bahorka M., Yurchenko N., Pshychenko O., Kyrylchuk K., Kharchenko S., Kovalenko I. (2023). Dynamics of productivity of leguminous plant groups during long-term use on different nutritional backgrounds. *Journal of Ecological Engineering, 24*(6), 190–196. https://doi.org/10.12911/22998993/162778
23. Kolisnyk O., Yakovets L., Amons S., Butenko A., Onychko V., Tykhonova O., Hotvianska, A., Kravchenko N., Vereshchahin I., Yatsenko V. (2024). Simulation of high–product soy crops based on the application of foliar fertilization in the conditions of the right bank of the forest steppe of Ukraine. *Ecological Engineering & Environmental Technology, 25*(7), 234–243. https://doi.org/10.12912/27197050/188638
24. Kołodziejczyk M. (2015). The effect of living mulches and conventional methods of weed control on weed infestation and potato yield. *Scientia Horticulturae, 191*, 127–133. https://doi.org/10.1016/j.scienta.2015.05.016
25. Kong C., Zhang S., Li Y., Xia Z., Yang X., Meiners S. & Wang P. (2018). Plant neighbor detection and allelochemical response are driven by root-secreted signaling chemicals. *Nature Communications, 9*, 1–9.
26. Kovalenko V., Kovalenko N., Gamayunova V., Butenko A., Kabanets V., Salatenko I., Kandyba N., Vandyk M. (2024). Ecological and technological evaluation of the nutrition of perennial legumes and their effectiveness for animals. *Journal of Ecological Engineering, 25*(4), 294–304. https://doi.org/10.12911/22998993/185219
27. Kovalzhy N., Rieznik S., Butenko A., Havva D., Degtyarjov V., Hotvianska A., Bondarenko O., Nozdrina N. (2024). Activity of cellulose–degrading microorganisms in typical chernozem under different fertilization systems of strawberries (*Fragaria*). *Agriculture and Forestry, 70*(3), 105–113. https://doi.org/10.17707/AgricultForest.70.3.07

28. Kunz C., Sturm D., Varnholt D., Walker F. & Gerhards R. (2016). Allelopathic effects and weed suppressive ability of cover crops. *Plant, Soil and Environment, 62*, 60–66. https://doi.org/10.17221/612/2015-pse
29. Lawley Y.E., Weil R.R. & Teasdale J.R. (2011). Forage radish cover crop suppresses winter annual weeds in fall and before corn planting. *Agronomy Journal, 103*, 137–144. https://doi.org/10.2134/agronj2010.0187
30. Legris M., Nieto C., Sellaro R., Prat S. & Casal J. (2017). Perception and signalling of light and temperature cues in plants. *The Plant Journal, 90*, 683–697.
31. Li L., Zhao H. & Kong C. (2020). Loliolide the most ubiquitous lactone is involved in barnyardgrass-induced rice allelopathy. *Journal of Experimental Botany, 71*, 1540–1550.
32. Malinovsky F., Thomsen M., Nintemann S., Jagd L., Bourgine B., Burow M. & Kliebenstein D. (2017). An evolutionarily young defense metabolite influences the root growth of plants via the ancient TOR signaling pathway. *Elife, 6*, e29353.
33. McErlich A.F. & Boydston R.A. (2013). Current state of weed management in organic and conventional cropping systems. *Automation: The Future of Weed Control in Cropping Systems,* 11–32. https://doi.org/10.1007/978-94-007-7512-1_2
34. Melander B., Liebman M., Davis A.S., Gallandt E.R., Bàrberi P., Moonen A.-C., Rasmussen J., van der Weide R. & Vidotto F. (2017). Non-chemical weed management, in weed research: Expanding Horizons. *John Wiley & Sons, Ltd, Chichester,* 245–270: https://doi.org/10.1002/9781119380702.ch9
35. Mishchenko Y., Butenko A., Bahorka M., Yurchenko N., Skydan M., Onoprienko I., Hotvianska A., Tokman V. & Ryzhenko A. (2024). Justification of organic agriculture parameters in potato growing with economic and marketing evaluation. *Agro-Life Scientific Journal, 13*(1), 139–146. https://doi.org/10.17930/AGL2024115
36. Mishchenko Y., Kovalenko I., Butenko A., Danko Y., Trotsenko V., Masyk I., Zakharchenko E., Hotvianska A., Kyrsanova G. & Datsko O. (2022). Post-Harvest siderates and soil hardness. *Ecological Engineering & Environmental Technology, 23*(3), 54–63. https://doi.org/10.12912/27197050/147148
37. Ninkovic V., Rensing M., Dahlin I. & Markovic D. (2019). Who is my neighbor? Volatile cues in plant interactions. *Plant Signaling Behavior, 14*, 1634993.
38. Petit S., Cordeau S., Chauvel B., Bohan D., Guillemin J. P. & Steinberg C. (2018). Biodiversity-based options for arable weed management. *Agronomy for Sustainable Development, 38*, 1–21. https://doi.org/10.1007/s13593-018-0525-3
39. Price A.J. & Norsworthy J.K. (2013). Cover crops for weed management in southern reduced-tillage vegetable cropping systems. Weed Technology, 27, 212–217. https://doi.org/10.1614/wt-d-12-00056.1
40. Radchenko M., Trotsenko V., Butenko A., Masyk I., Bakumenko O., Butenko S., Dubovyk O., Mikulina M. (2023). Peculiarities of forming productivity and quality of soft spring wheat varieties. *Agriculture and Forestry, 69*(4), 19–30. https://doi.org/10.17707/AgricultForest.69.4.02
41. Santín-Montanyá M.I., Martín-Lammerding D., Zambrana E. & Tenorio J.L. (2016). Management of weed emergence and weed seed bank in response to different tillage, cropping systems and selected soil properties. *Soil and Tillage Research, 161*, 38–46. https://doi.org/10.1016/j.still.2016.03.007
42. Scherner A., Melander B. & Kudsk P. (2016). Vertical distribution and composition of weed seeds within the plough layer after eleven years of contrasting crop rotation and tillage schemes. *Soil and Tillage Research, 161*, 135–142. https://doi.org/10.1016/j.still.2016.04.005
43. Tykhonova O., Skliar V., Sherstiuk M., Butenko A., Kyrylchuk K., Bashtovyi M. (2021). Analysis of *Setaria glauca* (L.) p. beauv. population's vital parameters in grain agrophytocenoses. *Environmental Research, Engineering and Management*, 77*(*1), 36–46. https://doi.org/10.5755/j01.erem.77.1.25489
44. Voitovyk M., Butenko A., Prymak I., Mishchenko Yu., Tkachenko M., Tsiuk O., Panchenko O., Slieptsov Yu., Kopylova T., Havryliuk O. (2023). Influence of fertilizing and tillage systems on humus content of typical chernozem. *Agraarteadus, 34*(1), 44–50. https://doi.org/10.15159/jas.23.03
45. Voytovyk M., Butenko A., Prymak I., Tkachenko M., Mishchenko Y., Tsyuk O., Panchenko O., Kondratiuk I., Havryliuk O., Sleptsov Y. & Polyvanyi A. (2024). Mobile phosphorus presence of typical chernozems on fertiliser system. *Rural Sustainability Research, 51*(346), 58–65. https://doi.org/10.2478/plua-2024-0006