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RESEARCH ARTICLE

Weed infestation of corn in organic crop rotation in the North-Eastern forest steppe of Ukraine

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Abstract

Weed density in corn crops cultivated under organic technology was assessed on typical medium-loam black soil. Winter wheat was the predecessor crop for corn. The study determined that the dominant weed species in the fields included *Chenopodium album* (white goosefoot), *Echinochloa crusgalli* (barnyard grass), and *Amaranthus retroflexus* (redroot pigweed). The effect of tillage on weed density was substantial, reducing *Chenopodium* by 79%, *Echinochloa* by 71%, *Convolvulus arvensis* (field bindweed) by 73%, *Amaranthus* by 53%, *Polygonum* (knotweed) by 46%, and other species such as *Thlaspi* by 27%, or with minimal impact. Plowing significantly decreased the presence of *Chenopodium* and *Echinochloa*, while *Amaranthus* density remained higher than in other variants. *Convolvulus arvensis* tended to thrive with shallow tillage at a depth of 12 cm-14 cm using a light cultivator.

Keywords: Tillage, Organic farming, Plowing, Disking, Corn, Weed, Soil fertility

Introduction

Agricultural crop yield and weed infestation are influenced by factors such as soil density and productive soil moisture reserves, which are contingent on the selected crop-growing technology, including tillage and plant protection systems (Kolisnyk et al., 2020a; Saveryn & Kachmar, 2023). In organic crop rotation, rational tillage is essential to minimize weed populations competing with crops (Zakharchenko et al., 2023). Corn, being a late-planted crop, faces challenges in weed control without pesticides. Currently, there are no organic-approved herbicides capable of targeting specific weed groups, so control strategies rely on tillage practices in fall, spring, and early plant development stages.

Soil and climate conditions dictate variations in tillage practices (Hristova et al., 2022; Mischenko et al., 2024; Lys et al., 2024). In the Northern Forest-Steppe, fall plowing combined with pre emergence spring loosening proved more effective in weed reduction than shallow fall tillage (Martyniuk et al., 2022). Studies in the Ivanivka district of Odessa region (Steppe zone) also highlighted the efficacy of plowing in organic farming, where weed infestation was lower, and crop yields were 11% and 14.8 quintals per hectare higher, respectively, than with disking at 14 cm-16 cm and 10 cm-12 cm depths, without using stubble decomposers (Albul, 2018; Kolisnyk et al., 2020b; Karpenko et al., 2020).

While many advocate for minimizing soil degradation through reduced or no-till practices (Tertychna et al., 2020; Karpenko et al., 2023), organic farming requires careful field selection, particularly for row crops like corn, which pose a high risk of weed infestation (Zakharchenko et al., 2024). Green manure crops are prioritized in organic systems, yet extreme weather (e.g., in 2024) can render green manure sowing unfeasible due to prolonged drought and high temperatures. To compete with potential weeds and maintain self-protection, soil should be covered with mulch or early sowing techniques should be applied. Crop rotation, seeding rate also influences weed management, particularly after corn or sunflower monocultures (Kolisnyk et al., 2020c; Kharchenko et al., 2021; Prymak et al., 2023; Simon et al., 2024). Selecting cereals and legumes as predecessors helps to reduce weed biomass and limit seed dispersal in the field.

In the EU and the United Kingdom, the agricultural sector is geared towards livestock production, where organic crop cultivation is closely tied to cattle grazing, free-range systems, and the use of organic fertilizers and compost on fields. The absence of such measures in organic crop fields reduces potential yields and leads to a negative phytosanitary status, lowering soil fertility (Vincent-Caboud et al., 2017; Parkhomenko et al., 2021; Adamchyk et al., 2023).

Materials and Methods

The research was conducted in the fields of a stationary experiment of the Department of Agriculture of the Institute of Agriculture of the North-East (Sad village, Sumy district, Sumy region). The soil cover of the experimental field is typical low-humus slightly leached chernozem with a coarse-silty medium loamy texture, with the following agrochemical indicators of the arable layer (at the time of the experiment's establishment): humus content by Tyurin method 4.3%; pH_{KCl} 6.0; content of easily hydrolyzable nitrogen by Kornfield – 104; mobile compounds of P_2O_5 and K_2O by Chirikov, respectively, 72.4 mg and 75.7 mg per 1 kg of soil. The granulometric composition of the soil by Kachynskyi is coarse-silty-medium-loamy: in the 0-20 cm layer, the physical clay (particles 0.05 mm-0.01 mm) is 49.1%-52.1%, silt (particles less than 0.001 mm) is 23.4%-25.5%.

The experiment scheme includes 4 variants of primary tillage for corn in the rotation from 4 crops: 1. Plowing to a depth of 20 cm-22 cm (Control – V1); 2. Deep soil loosening to a depth of 35 cm-40 cm – V2; 3. Husking disk cultivation to a depth of 12 cm-14 cm – V3 (by heavy cultivator); 4. Stubble cultivation (by light cultivator) to a depth of 12 cm-14 cm – V4.

The research is conducted in four-field crop rotations: the first rotation includes soya – winter wheat – corn – oat. The placement of the variants and repetitions is systematic, with three repetitions. The cultivation techniques for growing crops, except for the primary tillage, are generally accepted for the northeastern Forest-Steppe of Ukraine. Weed were calculated in 1 m^2 plots.

Statistical processing of research results was performed using the dispersion method with the application of the Excel software package.

Results and Discussion

Weed counts were conducted on June 14 during the years 2023-2024, when corn was in the V4 development phase by BBCH. Across all tillage variants, dominant weeds were observed - primarily annual monocots such as *Chenopodium album* L. (white goosefoot), *Echinochloa crus-galli* L. (barnyard grass), and *Amaranthus retroflexus* L. (redroot pigweed). Other species frequently encountered included *Polygonum*, *Convolvulus arvensis* (field bindweed), and to a lesser extent, *Thlaspi arvense* L., *Portúlaca olerácea* L., *Viola arvensis* (Murr., field pansy), and *Solanum nigrum* L. (black nightshade) (Fig. 1, and Tab. 1).

Table 1. Group of weeds depend on soil tillage.

Tillage	Total	Chenopodium	Echinochloa	Amaranthus	Polygonum	Convolvulus	Thlaspi	Portúlaca	Viola	Solanum
V1	113.5	34.5	62	12	1	2.5	0.5	0.5	0.5	0
V2	210	102.5	100	5	1.5	0.5	0	0	0.5	0
V3	206.5	83	118.5	2	0	2.5	0	0	0	0.5

V4	216.5	105.5	105	1.5	0	4	0.5	0	0	0
LSD_{05}		20.1	26.32	6.6	0.6	1.32	0.5	0.5	0.5	0.5

For *Chenopodium album*, plowing significantly reduced its density, as indicated by comparisons with other tillage methods and confirmed by an LSD_{05} value of 20.1 plants/m². No statistically significant difference was found between non-inversion tillage treatments, specifically deep loosening and variant 4 (disking). Tillage impacted *Chenopodium* density by 73%, with plot counts ranging from 10 plants per square meter to 180 plants per square meter.

For *Echinochloa crus-galli*, plant density ranged from 0-230 plants/m². Similar to *Chenopodium*, the lowest count was obtained with plowing, with no statistically significant difference found among variants 2, 3, and 4 according to an LSD_{05} of 26.32. On average, plowing resulted in 62 plants, deep loosening 100, heavy cultivator tillage 118.5, and light cultivator tillage 104.5 plants per square meter. Tillage had a 71% impact on plant density.

Amaranthus retroflexus density was lower than the previous species, ranging from 15 plants/m² to 120 plants/m². The highest density was recorded in the plowing variant. Differences among variants 2, 3, and 4 were within the LSD_{05} threshold of 6.66 plants/m². The tillage factor's effect on *Amaranthus* density was 53%.

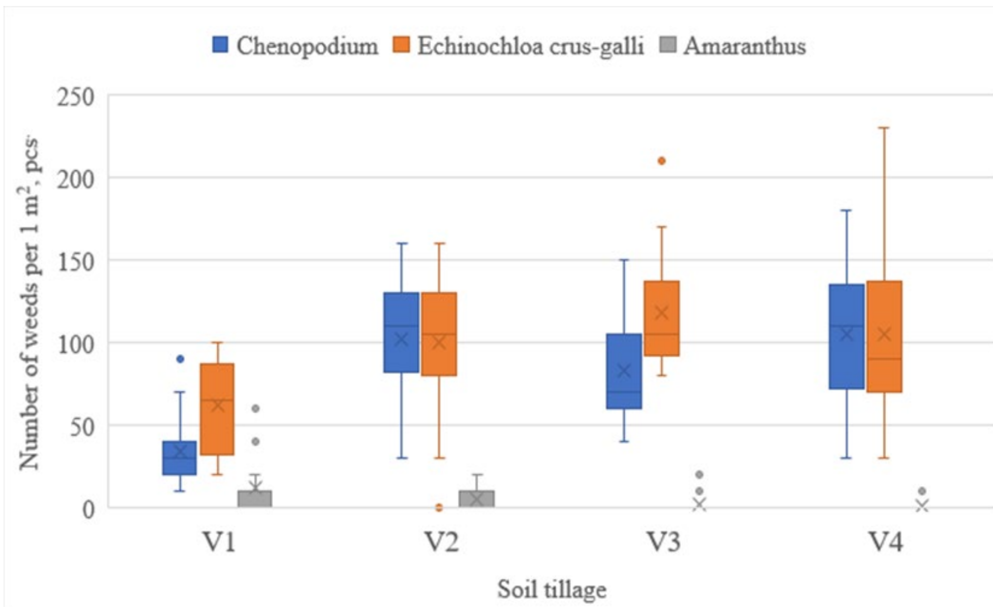

Figure 1. Dependence some species of weeds from tillage.

The annual *Polygonum* species showed densities of 0-60 plants per square meter, and this weed was absent in treatments with tillage depths of 12 cm-14 cm. No difference was found between variants 1 and 2.

Convolvulus arvensis (field bindweed) was counted at 1.95 plants/m²-15.99 plants/m² with an LSD of 1.32, with no difference observed between variants 1 and 3. Differences were observed among other variants, with the highest density recorded in variant 4.

The densities of other weed species remained within the LSD range.

Conclusions

- Autumn tillage predominantly affects weed density. Plowing generally results in significant reductions in the densities of annual monocots and taproot-bearing plants. Plowing is the best tillage in organic cultivation of corn, total number of weed reduced to 50% compared with surface and deep tillage without converting of soil mass.

- *Chenopodium album*, *Echinochloa crus-galli*, and *Amaranthus retroflexus* are the most prevalent weeds in organic corn fields, leading to substantial field infestations.
- There is minimal difference in weed density impact between heavy and light cultivators.

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