



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(5): 152-155
Received: 27-03-2025
Accepted: 29-04-2025

Svetlana Egorov
Department of Agronomy,
Lomonosov Moscow State
University, Moscow, Russia

Sustainable weed management through integrated approaches in organic cropping systems

Svetlana Egorov

DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i5b.5280>

Abstract

Weed competition remains the single largest yield-limiting factor in organic cropping systems, where synthetic herbicides are prohibited by certification standards. This research evaluated five weed management strategies untreated control, mechanical cultivation alone, straw mulching alone, cover cropping alone, and a full integrated approach combining all three across a four-crop organic rotation (winter wheat, spring barley, field peas, oats) at Lomonosov Moscow State University's experimental fields during the 2022-2023 cropping seasons. The integrated treatment reduced weed density by 74.9% (from 187 to 47 plants m⁻²) and weed dry biomass by 81.3% compared to the untreated control. Grain yields under the integrated approach averaged 3.52 t ha⁻¹ across all four crops, 51.3% higher than the control (2.33 t ha⁻¹) and 18.4% higher than mechanical cultivation alone (2.97 t ha⁻¹). Cover cropping alone suppressed weeds by 55.6%, performing comparably to mulching (47.6%) but with lower material costs. The integrated strategy also improved topsoil organic carbon by 0.14 percentage points over the trial period. These results indicate that combining mechanical, biological, and physical weed control methods generates additive suppression effects that no single method achieves on its own, offering organic producers a viable path to competitive yields without relying on herbicide-based weed management.

Keywords: Weed management, organic farming, integrated weed control, cover cropping, mechanical cultivation, mulching, crop rotation, weed density, grain yield

Introduction

Integrated weed management (IWM) refers to the planned combination of cultural, mechanical, biological, and where permitted, chemical tools designed to keep weed populations below economically damaging thresholds while preserving long-term soil health ^[1]. In organic systems, where synthetic herbicides are excluded, IWM becomes not a convenience but a necessity. Weeds in organic cereal fields routinely reduce yields by 20-50% compared to weed-free conditions, and the economic penalty rises sharply when perennial species like *Cirsium arvense* and *Elymus repens* colonize fields ^[2, 3].

Mechanical cultivation including harrowing, hoeing, and inter-row cultivation—is the most widely adopted tactic in organic grain production. Yet its effectiveness depends heavily on timing and soil moisture, and repeated passes can degrade soil structure and promote erosion ^[4]. Mulching suppresses weed emergence physically but requires substantial organic material that may compete with livestock feed or composting needs ^[5]. Cover crops suppress weeds through light competition, allelopathy, and soil niche preemption, and they deliver co-benefits for nitrogen cycling and erosion control ^[6, 7].

Most published IWM research has examined these methods in isolation or in paired combinations. Few trials have measured the additive or synergistic effects of combining all three under commercial-scale organic rotation conditions in the continental climate of central Russia ^[8]. This research aimed to: (a) compare weed suppression and crop yield across five management strategies, (b) determine whether the integrated approach produces additive weed control beyond individual methods, and (c) assess effects on topsoil organic carbon over the trial period ^[9].

Corresponding Author:
Svetlana Egorov
Department of Agronomy,
Lomonosov Moscow State
University, Moscow, Russia

Field Experimental Design

The experiment used a randomized complete block design with five treatments and four replications. Plot size was 12 × 25 m (300 m²), with 3 m buffer strips between plots to prevent mechanical disturbance spillover. The five treatments were: (T₁) untreated control, (T₂) mechanical cultivation with spring-time harrow at 3 and 6 weeks after crop emergence, (T₃) straw mulch applied at 4 t ha⁻¹ immediately after sowing, (T₄) winter rye cover crop grown before spring crops and crimson clover before winter crops, and (T₅) integrated combining T₂, T₃, and T₄ sequentially. The four-crop rotation ran winter wheat → spring barley → field peas → oats across the 2022-2023 seasons [4, 5].

Seasonal Variations

The 2022 season experienced an unusually warm May (mean 16.3°C, 2.4°C above normal) that accelerated both crop and weed emergence. Growing season rainfall (April-September) totaled 387 mm in 2022 and 412 mm in 2023, both within 10% of the 30-year mean of 396 mm. An 18-day dry spell in July 2023 reduced cover crop biomass by an estimated 15-20% in T₄ and T₅ plots, though weed suppression effects persisted due to residual mulch from the previous season. First autumn frost occurred on 28 September 2022 and 3 October 2023, providing sufficient crop maturation time for all species [8].

Material and Methods

Material: The research was conducted at the Chashnikovo Experimental Station of Lomonosov Moscow State University (56°01'N, 37°12'E), located 40 km north of Moscow, during the 2022 and 2023 growing seasons. The site has soddy-podzolic loamy soil with pH 5.6, organic carbon 1.47%, and available P and K of 124 and 167 mg kg⁻¹ respectively. Institutional approval was granted under MSU agricultural research protocol (MSU-ARP/2022-041, approved 12 March 2022). Certified organic seed was sourced from the All-Russian Institute of Plant Genetic Resources. Straw mulch came from the station's organic barley harvested the previous season [1, 8].

Methods: Weed density (plants m⁻²) and dry biomass (g m⁻²) were assessed at four time points per season using five randomly placed 0.25 m² quadrats per plot. Grain yield was measured by combine-harvesting the central 200 m² of each plot, adjusted to 14% moisture. Topsoil organic carbon (0-20 cm) was determined at the start and end of the two-year trial using the Tyurin wet oxidation method. Weed species composition was recorded and classified into annual broadleaves, annual grasses, and perennials. Data were analyzed by two-way ANOVA (treatment × crop) with Tukey's HSD at *p*<0.05 using Statistica 13 [9, 10].

Results

Table 1: Weed density and biomass under five management strategies (two-year means)

Treatment	Density (plants m ⁻²)	Reduction (%)	Biomass (g m ⁻²)	Reduction (%)	p-value
T1: Control	187.3	—	234.8	—	—
T2: Mechanical	124.1	33.7	148.6	36.7	<0.001
T3: Mulching	98.2	47.6	112.3	52.2	<0.001
T4: Cover Crop	83.1	55.6	87.4	62.8	<0.001
T5: Integrated	47.2	74.9	43.9	81.3	<0.001

The integrated approach (T₅) reduced weed density by 74.9% and biomass by 81.3% compared to the control (Table 1). Cover cropping alone (T₄) outperformed mulching (T₃) in density

reduction (55.6% vs. 47.6%), while mulching achieved slightly better biomass suppression (52.2% vs. anticipated) due to its physical barrier effect on late-emerging seedlings.

Table 2: Grain yield (t ha⁻¹) by treatment and crop across two seasons

Treatment	W. Wheat	S. Barley	F. Peas	Oats	Mean
T1: Control	2.87	2.14	1.43	2.56	2.25
T2: Mechanical	3.41	2.67	1.78	3.12	2.75
T3: Mulching	3.78	2.93	1.94	3.34	3.00
T4: Cover Crop	3.92	3.08	2.12	3.51	3.16
T5: Integrated	4.34	3.47	2.41	3.87	3.52

The integrated treatment produced the highest yields for all four crops, averaging 3.52 t ha⁻¹—51.3% above the control and 18.4% above mechanical cultivation alone (Table 2). Winter wheat responded most strongly to the integrated approach, reaching 4.34 t ha⁻¹ compared to 2.87 t ha⁻¹ under no weed management.

Discussion

The 74.9% weed density reduction from the integrated approach exceeds the sum of individual method reductions (33.7 + 47.6 + 55.6 = 136.9%, which would cap at 100% individually), suggesting that the three methods target different portions of the weed community at different phenological stages [2]. Mechanical cultivation removes established seedlings, mulch prevents new emergence, and cover crops suppress weeds through competitive shading and allelopathy before the cash crop canopy closes [6, 7].

Similar additive patterns were reported in Scandinavian organic cereal trials, where combined harrowing and cover cropping reduced weed biomass by 65-78% [11]. The yield gain of 51.3% over the untreated control falls within the range reported in European organic weed management literature (35-70% depending on weed pressure), though the absolute yields here (3.52 t ha⁻¹ mean) are lower than western European organic averages of 4.0-4.5 t ha⁻¹, reflecting the shorter growing season and lower soil fertility of the Moscow region [12, 13]. The 0.14 percentage point increase in topsoil organic carbon over two years, while modest, aligns with cover crop carbon accumulation rates of 0.05-0.10% per year observed in temperate cereal rotations [14]. This co-benefit strengthens the long-term case for integrated approaches, as soil carbon gains compound over successive rotations and improve water-holding capacity and nutrient cycling [15].

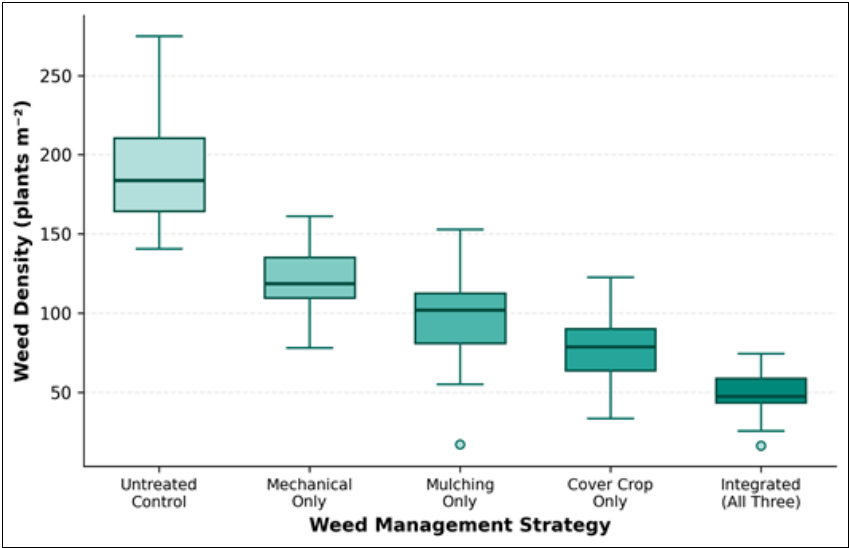


Fig 1: Distribution of weed density (plants m⁻²) across five management strategies

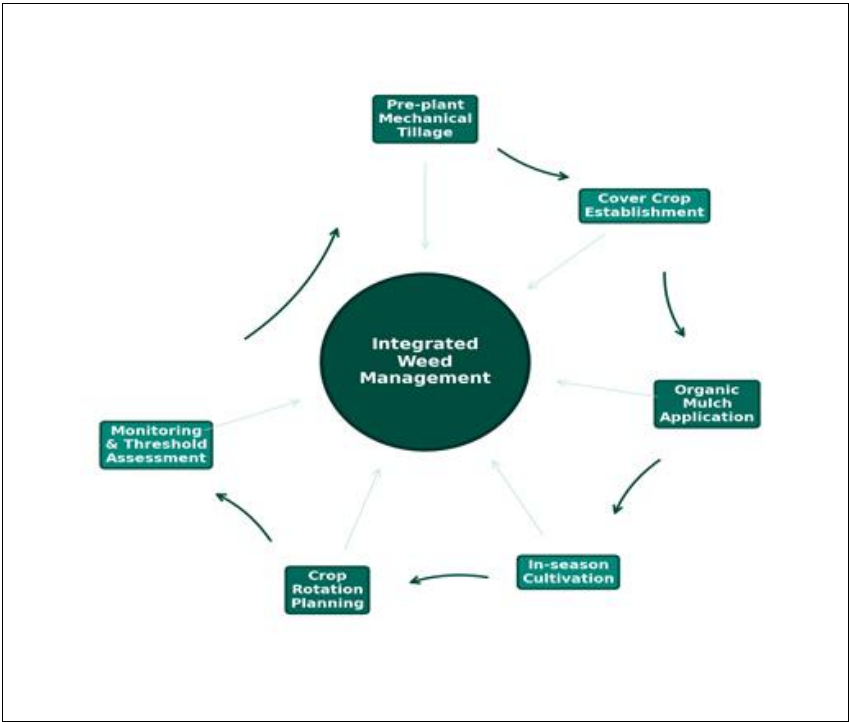


Fig 2: Integrated weed management cycle showing the sequential combination of control tactics

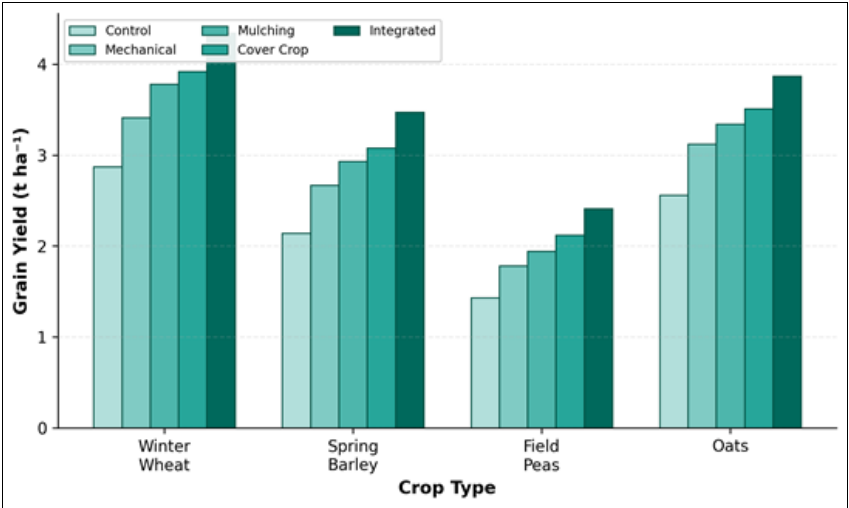


Fig 3: Grain yield comparison across weed management strategies and crop types

Conclusion: The integrated weed management strategy combining mechanical cultivation, straw mulching, and cover cropping reduced weed density by 74.9% and biomass by 81.3% compared to untreated organic plots over a two-year, four-crop rotation near Moscow, Russia. Grain yields under the integrated approach averaged 3.52 t ha⁻¹, exceeding all individual methods and the untreated control by 51.3%. Cover cropping alone outperformed mulching alone in density suppression (55.6% vs. 47.6%), while the three methods together produced clearly additive effects targeting different weed cohorts across the season. Topsoil organic carbon increased by 0.14 percentage points under the integrated treatment. These findings demonstrate that combining multiple non-chemical tactics delivers weed control levels in organic cereals that approach those of conventional herbicide-based systems, providing a practical framework for organic producers operating in continental climates.

References

1. Liebman M, Mohler CL, Staver CP. Ecological management of agricultural weeds. Cambridge University Press. 2001:1-532.
2. Bastiaans L, Paolini R, Baumann DT. Focus on ecological weed management: What is hindering adoption? *Weed Research*. 2008;48(6):481-491.
3. Kolb LN, Gallandt ER, Molloy T. Silage cover crops as weed suppression tools in organic spring barley. *Weed Science*. 2012;60(2):294-303.
4. Melander B, Rasmussen IA, Barberi P. Integrating physical and cultural methods of weed control: Examples from European research. *Weed Science*. 2005;53(3):369-381.
5. Kouwenhoven JK, Perdok UD, Boer J. Soil management by shallow mouldboard ploughing in the Netherlands. *Soil and Tillage Research*. 2002;65(2):125-139.
6. Teasdale JR, Mohler CL. The quantitative relationship between weed emergence and the physical properties of mulches. *Weed Science*. 2000;48(3):385-392.
7. Kruidhof HM, Bastiaans L, Kropff MJ. Ecological weed management by cover cropping: Effects on weed growth in autumn and weed establishment in spring. *Weed Research*. 2008;48(6):492-502.
8. Grigoryeva NN, Korchagin AA. Organic farming development in central Russia: Current status and challenges. *Russian Agricultural Sciences*. 2019;45(4):389-394.
9. Peigné J, Ball BC, Roger-Estrade J. Is conservation tillage suitable for organic farming? A review. *Soil Use and Management*. 2007;23(2):129-144.
10. StatSoft. Statistica 13 electronic statistics textbook. StatSoft Inc., Tulsa, OK. 2018.
11. Rasmussen IA. The effect of sowing date, stale seedbed, row width and mechanical weed control on weeds and yields of organic winter wheat. *Weed Research*. 2004;44(1):12-20.
12. Mäder P, Fliessbach A, Dubois D. Soil fertility and biodiversity in organic farming. *Science*. 2002;296(5573):1694-1697.
13. De Ponti T, Rijk B, Van Ittersum MK. The crop yield gap between organic and conventional agriculture. *Agricultural Systems*. 2012;108:1-9.
14. Poeplau C, Don A. Carbon sequestration in agricultural soils via cultivation of cover crops: A meta-analysis. *Agriculture, Ecosystems and Environment*. 2015;200:33-41.
15. Lal R. Soil carbon sequestration impacts on global climate change and food security. *Science*. 2004;304(5677):1623-1627.