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AGREEMENT ON REDUCING CHEMICAL HERBICIDE USE IN AGRICULTURE BETWEEN NARDI AND AGROLYNX ZRT

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Abstract. *This article is part of an ongoing collaborative project between the National Agricultural Research and Development Institute (NARDI) and AgroLynx Zrt witch is centered on the need to reduce the use of chemical herbicides in agriculture while maintaining high crop yields. It adopts a case study approach to explore alternative solutions aimed at reducing or eliminating synthetic herbicide use. Agroecological weed management practices will be compared with conventional chemical herbicide applications under field conditions. Field experiments were conducted to evaluate the effects of agroecological weed management (AWM) practices and a natural herbicide based on pelargonic acid on crop performance and weed infestation. The study focuses on two cropping systems, with one crop per year: sunflower (2024–2025) and wheat (2025–2026), under organic farming conditions in Fundulea, Romania. In addition to field experimentation, the research includes soil microbiome analysis based on samples collected from four experimental plots. Environmental parameters will also be monitored through the installation of specific sensors to record meteorological data, soil temperature, soil moisture, and water pH. The project aims to provide integrated insights into sustainable weed management strategies by combining agronomic performance data with soil biological and environmental indicators, contributing to the development of environmentally friendly agricultural practices.*

Keywords:*agroecological weed management, chemical herbicides, field conditions, pelargonic acid, crop performance, organic farming*

INTRODUCTION

The reduction of reliance on synthetic herbicides represents a major objective in sustainable agriculture, driven by increasing concerns related to soil degradation, biodiversity loss, and the emergence of herbicide-resistant weed populations (DUKE, 2012; HEAP, 2022; TILMAN ET AL., 2017). Within this context, the study addresses a relevant and timely research question, aiming to identify effective agroecological alternatives that can maintain high crop productivity while minimizing environmental impact (MORAIS ET AL., 2015; WEZEL ET AL., 2014).

The methodological framework is based on a case study approach, providing an applied experimental setting in which agroecological weed control practices are evaluated in comparison with conventional chemical herbicide treatments. Specifically, two agroecological weeding methods and one natural herbicide are tested to assess their effectiveness in controlling weed populations and their influence on the soil–plant system (ZIMDAHL, 2018).

A central component of the study is the analysis of the soil microbiome, given the critical role of microbial communities in nutrient cycling, soil fertility, and ecosystem resilience (VAN DER HEIJDENAN ET AL., 2008).

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In parallel, environmental parameters will be continuously monitored using sensors installed in proximity to the experimental plots by a consortium partner, generating data on pedoclimatic conditions that may influence both weed dynamics and microbial community structure (PHILIPPOT ET AL., 2017).

By integrating agronomic, microbiological, and environmental data, this study aims to provide a comprehensive assessment of agroecological alternatives to synthetic herbicides, contributing to the development of sustainable weed management strategies aligned with the principles of modern agriculture (ALTIERI, 1995; DARMENCY, 2018).

MATERIAL AND METHODS

Plant material and crop management

The biological material used in the experiment was the sunflower (*Helianthus annuus L.*) hybrid FD15E27, developed by NARDI Fundulea.

Soil preparation included autumn ploughing (October 2024), following stubble cultivation, and spring seedbed preparation consisting of discing and harrowing after nitrogen fertilization. Sowing was carried out on 24 April 2025 at a density of 60.000 viable seeds ha^{-1}, with a sowing depth of 4–5 cm.

Seeds were treated with fungicides prior to sowing. Fertilization included the application of triple superphosphate (150 kg ha^{-1}) before ploughing and urea (200 kg ha^{-1}) in early spring, resulting in total inputs of 92 kg N ha^{-1} and 69 kg P_2O_5 ha^{-1}.

One irrigation event was applied during the growing season (17–18 June 2025) using a drip system, with a norm of 200 m^3 ha^{-1} (FAO, 2017; ZIMDAHL, 2018).

Experimental design and treatments

The experiment was organized as a randomized complete block design with five replications, a standard approach for field evaluation of agronomic treatments to reduce spatial variability effects (TADESSE, 2018). Each experimental plot had a surface area of 42 m^2 (4.2 m × 10 m), comprising six rows, with 2 m-wide protective alleys between plots. The total experimental area was 1302 m^2.

Five weed management variants were evaluated: (V1) false seedbed, (V2) mechanical treatment, (V3) natural herbicide treatment based on pelargonic acid, (V4) conventional herbicide application (on-farm practice), and (V5) untreated control.

The false seedbed treatment (V1) consisted of early soil preparation to stimulate weed germination, followed by destruction of emerged weeds prior to sowing, a widely used ecological weed suppression technique (BOND & GRUNDY, 2001).

The mechanical treatment (V2) involved inter-row cultivation performed during early post-emergence stages (23 May 2025).

The natural herbicide treatment (V3) consisted of a pre-sowing application of pelargonic acid at a dose of 20 L ha^{-1} (500 g L^{-1} active ingredient) diluted in 400 L ha^{-1} water (5% v/v solution), a contact herbicidal compound derived from fatty acids with rapid desiccation activity (DAYAN ET AL., 2012).

The conventional treatment (V4) included a pre-emergence application of Frontier Forte (0.80 L ha^{-1}, applied on 24 April 2025) and a post-emergence application of Leopard 5 EC (0.75 L ha^{-1}, applied on 30 May 2025).

The untreated control (V5) did not receive any weed control measures, except for a corrective manual hoeing applied later in the season to prevent total crop loss due to excessive weed pressure.

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Weed assessment protocol

Weed infestation was assessed through periodic field surveys conducted in predefined 1 m² sampling areas within each plot. Three assessment campaigns were performed during the growing season, corresponding to key crop development stages. Weed density was recorded by species, distinguishing between monocotyledonous (e.g., *Setaria spp.*, *Sorghum halepense*, *Echinochloa crus-galli*) and dicotyledonous species (e.g., *Amaranthus retroflexus*, *Chenopodium album, Polygonum spp.*). Data were expressed as number of weeds per square meter, following standard weed science assessment protocols (BOUTIN ET AL., 2014; ZIMDAHL, 2018).

Table 1

Analytical methods and instrumentation used in the sunflower field experiment

Section	Description of activityi	Monitored parameters	Units of measurement	References / Standards
Phenological observations	Monitoring crop development stages from sowing to maturity	BBCH scale, plant height, number of leaves	cm, no. plant^{-1}	Passaia et al. (2014);
Microbiome and soil	Soil sampling (5–15 cm depth) for microbiological analyses	Composition of microbial communities, sampling date	calendar date, cfu g^{-1} (colony forming units)	ISO 18400;
Environmental monitoring	Recording pedoclimatic data using IoT sensors and a weather station	Air/soil temperature, humidity, precipitation, solar radiation, water pH	°C, %, mm, W/m^2,	Standarde WMO; Ghiduri FAO
Yield and productivity	Mechanical harvesting and determination of grain quality	Yield per hectare, test weight (TW), thousand kernel weight (TKW), grain moisture	K·g·ha^{-1}, k·g·h·L^{-1}, g, %	ISO 7971; ISO 520

RESULTS AND DISCUSSIONS

Weed infestation dynamics under different management strategies

The different weed management strategies produced marked variations in weed density and species composition throughout the growing season. The untreated control (V5) consistently exhibited the highest weed pressure, confirming the strong competitive ability of weed communities in the absence of management interventions (ZIMDAHL, 2018; LIEBMAN & DAVIS, 2000). In contrast, all managed variants reduced weed infestation to varying degrees, with the most pronounced suppression observed in the pelargonic acid treatment (V3), particularly during early growth stages of sunflower.

Monocotyledonous weeds such as *Setaria spp.*, *Sorghum halepense*, and *Echinochloa crus-galli* were significantly reduced in the V3 treatment immediately after application, often reaching near-zero densities in early assessments. Similar trends were observed for dicotyledonous species, including *Amaranthus retroflexus* and *Chenopodium album*, which were strongly suppressed across most replicates. The rapid activity is consistent with the contact mode of action of fatty acid-based herbicides, which induce rapid membrane disruption and tissue desiccation (DAYAN ET AL., 2009; DAYAN ET AL., 2012).

Mechanical and false seedbed treatments (V1 and V2) provided intermediate levels of control, consistent with literature reporting variable long-term efficacy of non-chemical weed control strategies depending on environmental conditions and timing (BOND & GRUNDY, 2001; BUHLER, 2002). However, their effectiveness was less consistent over time, with a tendency for weed reinfestation in later growth stages.

Conventional herbicide management (V4) also provided effective weed suppression, although weed densities remained slightly higher compared to the pelargonic acid treatment in certain assessment windows, particularly for late-emerging dicotyledonous species. Overall, these results highlight that early-season weed control intensity is a critical determinant of final weed pressure (ZIMDAHL, 2018).

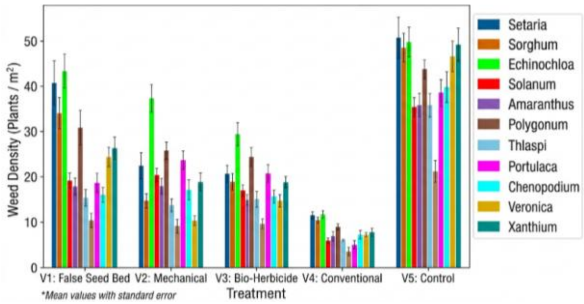

Figure 1. Effect of treatment on weed desnity by species

Crop performance and yield response

Yield data revealed significant differences among treatments, strongly associated with weed pressure dynamics and early competition effects on crop establishment (OERKE, 2006). The highest grain yield was recorded in the pelargonic acid treatment (V3), reaching 2.947 kg ha^{-1}, followed closely by the conventional herbicide variant (V4) with 2.888 kg ha^{-1}.

Both treatments significantly outperformed the untreated control (V5), which recorded the lowest yield at 2.010 kg ha^{-1}. Mechanical (V2) and false seedbed (V1) treatments resulted in intermediate yields, indicating partial but insufficient weed suppression under the conditions of the experiment.

The superior performance of V3 suggests that effective early weed control during the critical crop establishment phase is essential for maximizing yield potential. This aligns with established evidence that weed competition during early developmental stages has disproportionate effects on final productivity in annual crops (KNEZEVIC ET AL., 2002).

The comparable performance between pelargonic acid and conventional herbicides highlights the potential of non-synthetic alternatives to achieve similar agronomic outcomes under field conditions when properly timed.

Tabel 2

The influence of the treatment applied on the production and yield of sunflower

Nr.	Treatament	Production		Production increase
		(kg/ha)	%	Kg/ha
V1	False seed bed	2.601	129,40	591↑
V2	Mechanical treatment	2.617	130,19	607↑
V3	Natural Herbicide Treatment (Pelargonic acid)	2.947	146,61	937↑
V4	Conventional - On-farm Practice	2.888	143,68	878↑
V5	No treatment (witness)	2.010	100,00	0

Yield quality parameters

Quality indicators followed a similar pattern to yield results. Both hectolitre weight and thousand-kernel weight were lowest in the untreated control, reflecting the negative impact of weed competition on assimilate availability and grain filling processes (ZIMDAHL, 2018). In contrast, the pelargonic acid treatment recorded the highest values for both parameters, with a hectolitre weight of 41.5 kg hL^{-1} and a thousand-kernel weight of 75.44 g, indicating improved grain development and uniformity.

Conventional herbicide treatment showed slightly lower but comparable quality indices, while mechanical and false seedbed treatments provided moderate improvements over the control. These findings are consistent with studies demonstrating that weed competition reduces both yield quantity and grain quality through resource limitation during critical phenological stages (OERKE, 2006).

Tabel 3

The influence of the treatments applied on the quality indices for sunflower

Nr.	Treatament/	Hectoliter weight HW (kg/hl)			Weight of a thousand grains WTG (g)		
		Averge	%	Dif+Smf	Average	%	Dif+Smf
V1	False seed bed	40.9	106.0	2.3*	74.80	106.80	4.73*
V2	Mechanical treatment	40.8	105.7	2.2*	75.09	107.16	5.02*
V3	Natural Herbicide Treatment (Pelargonic acid)	41.5	107.5	2.9*	75.44	107.66	5.37*
V4	Conventional - On-farm Practice	41.0	106.2	2.4*	75.17	107.27	5.10*
V5	No treatment (witness)	38.6	100.00	0.0	70.07	100.00	0.0

CONCLUSIONS

The application of pelargonic acid demonstrated high efficacy in weed control, particularly during early growth stages of sunflower. The observed reduction in monocotyledonous and dicotyledonous weed species is consistent with the known rapid contact action of fatty acid-based herbicides (DAYAN ET AL., 2012).

This mode of action induces rapid desiccation of vegetative tissues, resulting in immediate damage to aboveground plant structures.

Overall, among the tested variants, the pelargonic acid treatment provided the most favorable balance between weed control efficiency and crop performance, confirming findings from previous studies on natural-product-based herbicides in integrated weed management systems (DUKE ET AL., 2009). Its effectiveness was strongly dependent on early application timing, reinforcing the importance of synchronizing weed control interventions with sensitive crop developmental stages (ZIMDAHL, 2018).

These results support the inclusion of pelargonic acid-based treatments in integrated weed management programs as a viable and environmentally compatible alternative to conventional herbicides, particularly within systems targeting reduced synthetic input dependency.

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